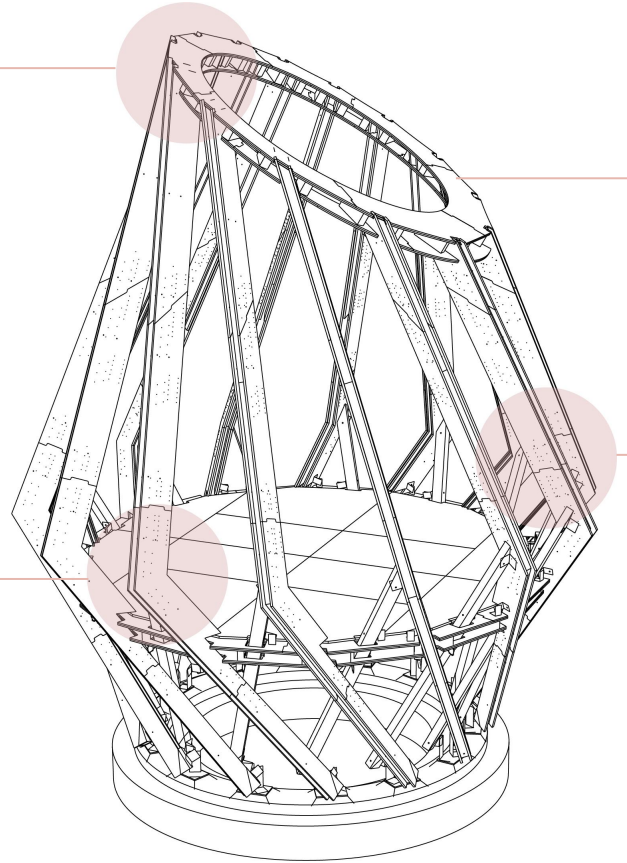
NEST 2.0
Bamboo Shading Hat

brenda freitas
frank feng
hanna lepperød
ilaena mariam napier

Original NEST Design | Aspects we have chosen to work on/change

Oculus size & increase angle

- Increase angle from 30 to 35 degrees
- Decrease oculus to a radius of 75cm



Skin, Ventilation & Shading

- Creating an outer skin layer made from bamboo for solar shading and wind protection

Number of ribs

- Reducing the number of ribs by half (from 14 to 7)

Connection of the ribs

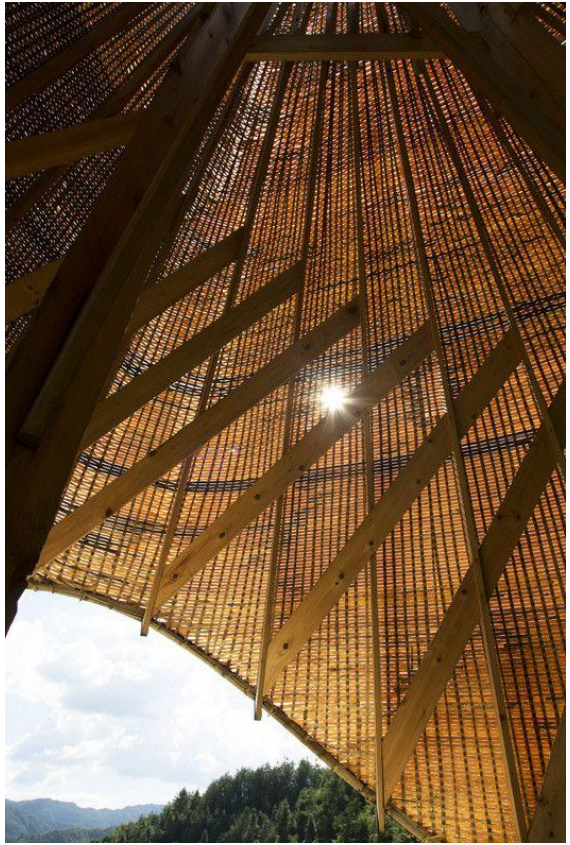
- Change the connection from a fixed joint to a pin joint connection in order to allow for movement
- Adding cable connections at some of these points for wind load

(Original NEST Structure)

Precedent | Sun Room Pavilion / Don Holohan / China



Rib structure similar to NEST

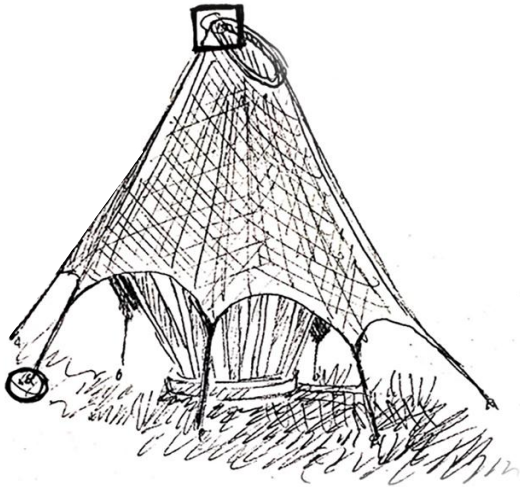


Woven bamboo skin over timber structure

- The pavilions are traditional structures/shelters for local farmers
- The form and siting of the pavilion are carefully considered to maximize ventilation and views
- Shelters from the elements (storms in the rainy season, sun in the hottest part of the day, and prevailing winds)
- Outer shell made from woven bamboo

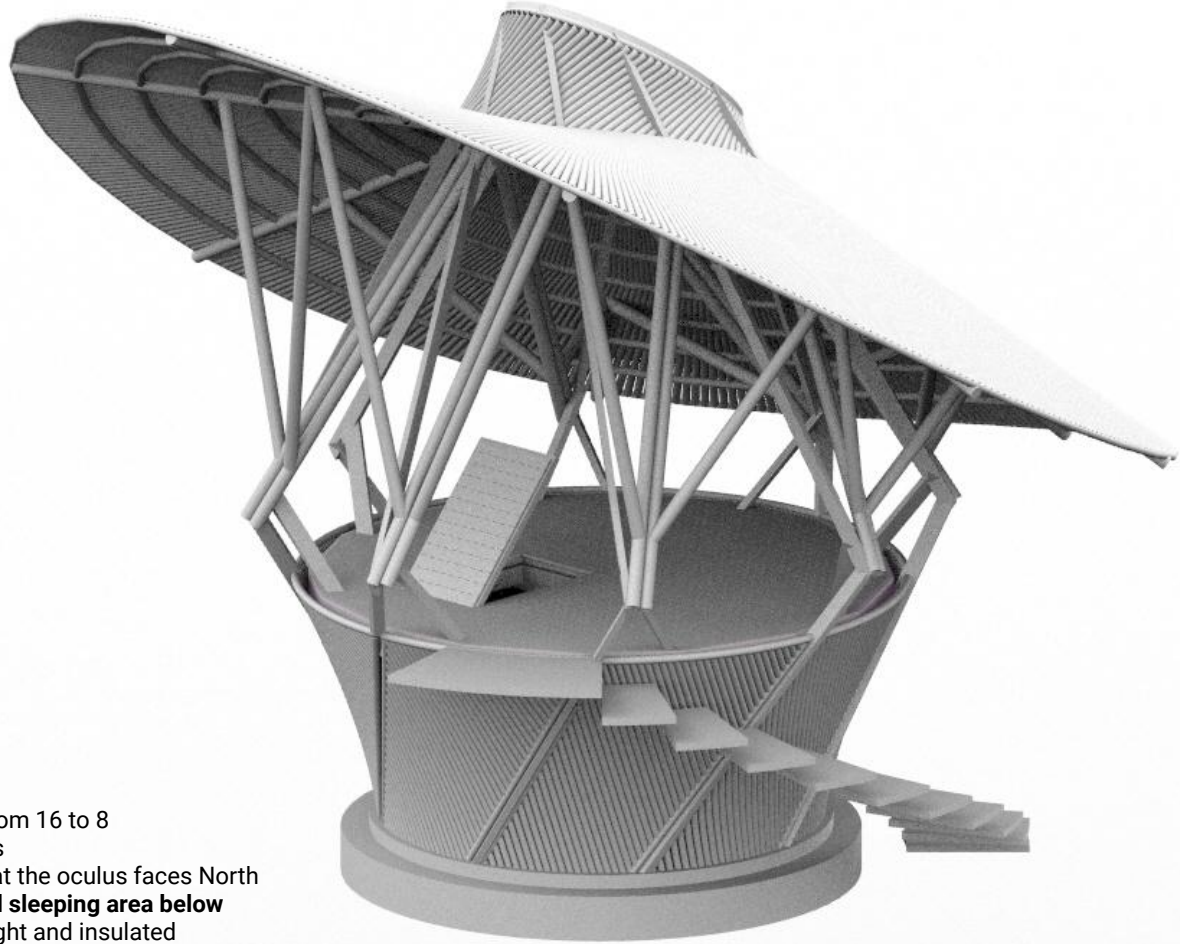
How to relate it to NEST:

- Perforated Skin



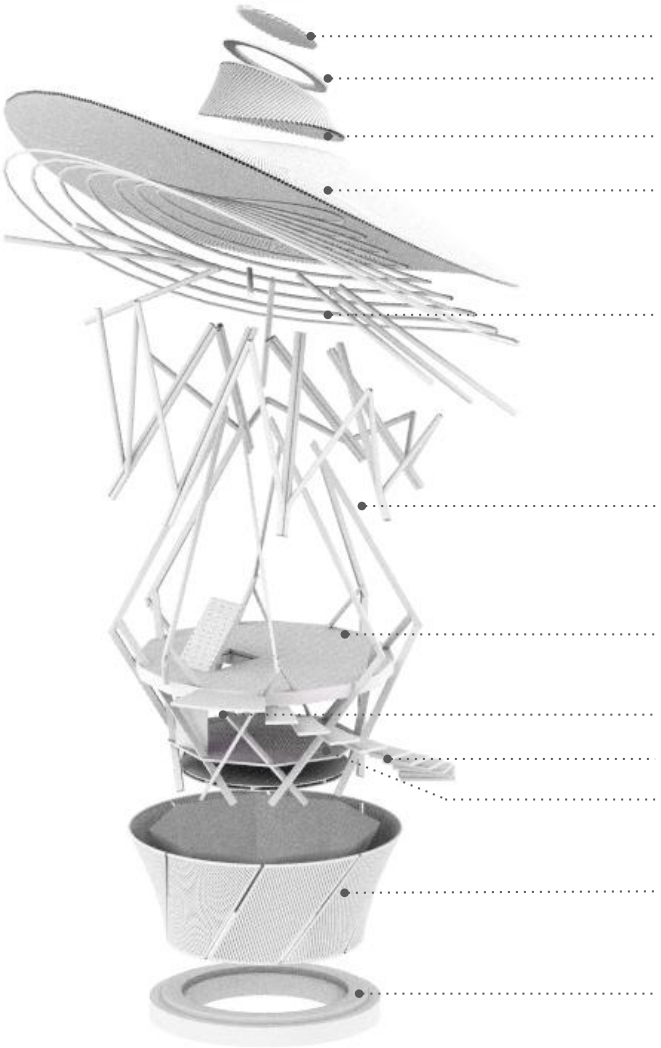
Initial Sketch of Woven Bamboo skin applied to NEST

New Proposed Rendered Design | Overall Concept



- Reduced the number of ribs from 16 to 8
- Reduced the size of the oculus
- Orientated the structure so that the oculus faces North
- **Create a living area above and sleeping area below**
- Make the bottom area watertight and insulated
- Create a bamboo shading device to protect the structure from the elements

Design | Exploded Axo



Bamboo louvers

Oculus

Bamboo half culm panels

Layered Bamboo half culm shading ‘hat’

Cross-braced curved Bamboo supports

Original inner timber ribs excluding plywood panels

Waterproof sloped timber floor with opening for access to sleeping area

Sleeping area (with platform and net) - sleeps up to 4 people

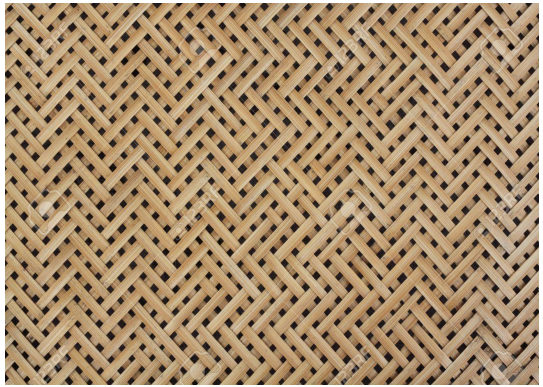
Timber stairs

Bottom flooring

Double skin - fabric (inner) + bamboo half culm panels attached to timber ribs (outer)

Original concrete foundation

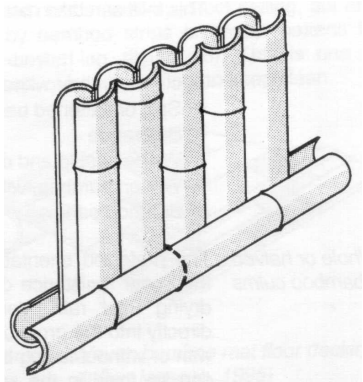
Materiality | Skin Strategy Options



Bamboo
-High compressive strength
-Lightweight
-As a skin, can provide strength and stability to the structure
-Fire resistant (up to 4000 C)
-Cost effective and easy to use
-**U Value:**
- **single layer: 2.065**
- **double layer: 1.040**
- **triple layer: 0.656**

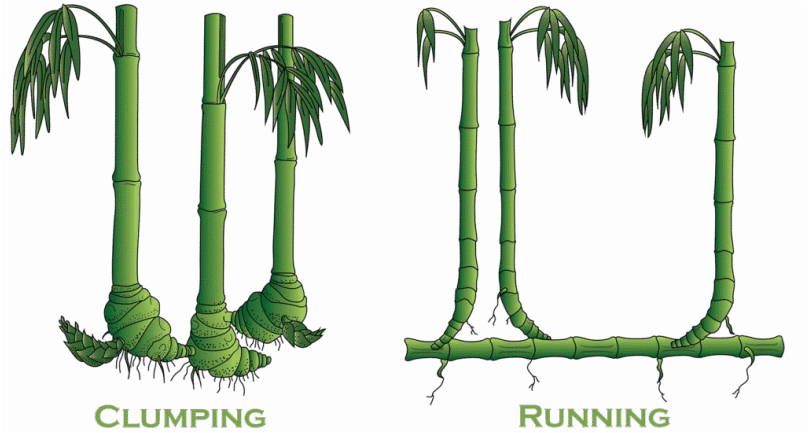


Timber
-Biodegradable, renewable resource
-Ease of construction and fabrication
-Versatile and visually appealing
-**U value: 0.64**



Bamboo Vertical Halved Culms
-High compressive strength
-Lightweight
-As a skin, can provide strength and stability to the structure
-Fire resistant (up to 4000 C)
-Cost effective and easy to use
-Water Resistant
- Bendable

Materiality | Bamboo Research



Running bamboo can be invasive and spread up to 4m per year

Clumping bamboo spreads very slowly and can be grown in pots

Eastern Nepal possesses 22 species of bamboo whereas 24, 12 and 9 species are found in central, western and mid-western Nepal respectively. Far western Nepal has not been explored properly.

Bamboos are abundant in eastern, central and western parts of Nepal. Large-statured bamboos are found mostly below 1000 m, whereas mostly small-statured bamboo or nigalo are distributed above 1400 m.

Eight species of bamboo, *Borinda chigar, B. emeryi, Cephalostachyum latifolium, Himalayacalamus asper, H. porcatus, Yushania microphylla, Arundinaria racemosa, Bambusa tulda,* are getting rare in Nepal.

10 Species used in construction:

- Ampelocalamus patellaris (Nibba, Ghopi bans, Lyas bans)
- Bambusa arundinacea
- B. balcooa (Dhanubans, Ban bans)
- B. nepalensis (Tamabans, Phusure bans)
- B. nutans subsp. Nutans (Tharubans, Sate bans)
- B. tulda (Kada bans, Karaicho bans, Chab bans) (rare)
- B. vulgaris (rare)
- D. hookeri (Kalo, Bhalu bans)
- D. strictus (Latthi bans) (becoming rare)
- *Melocanna baccifera* (Lahure bans)

https://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/572/ch29.htm

Failure:

"Bamboo as a composite structure and its mechanical failure behaviour "
R. Kappel, C. Mattheck, K. Bethge & I. Tesari Institute for Materials Research II, Forschungszentrum Karlsruhe, Germany

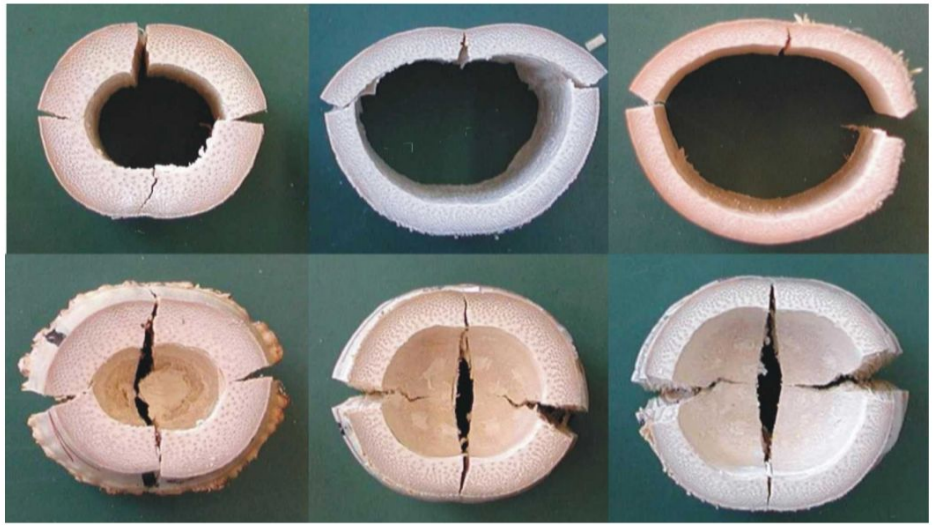


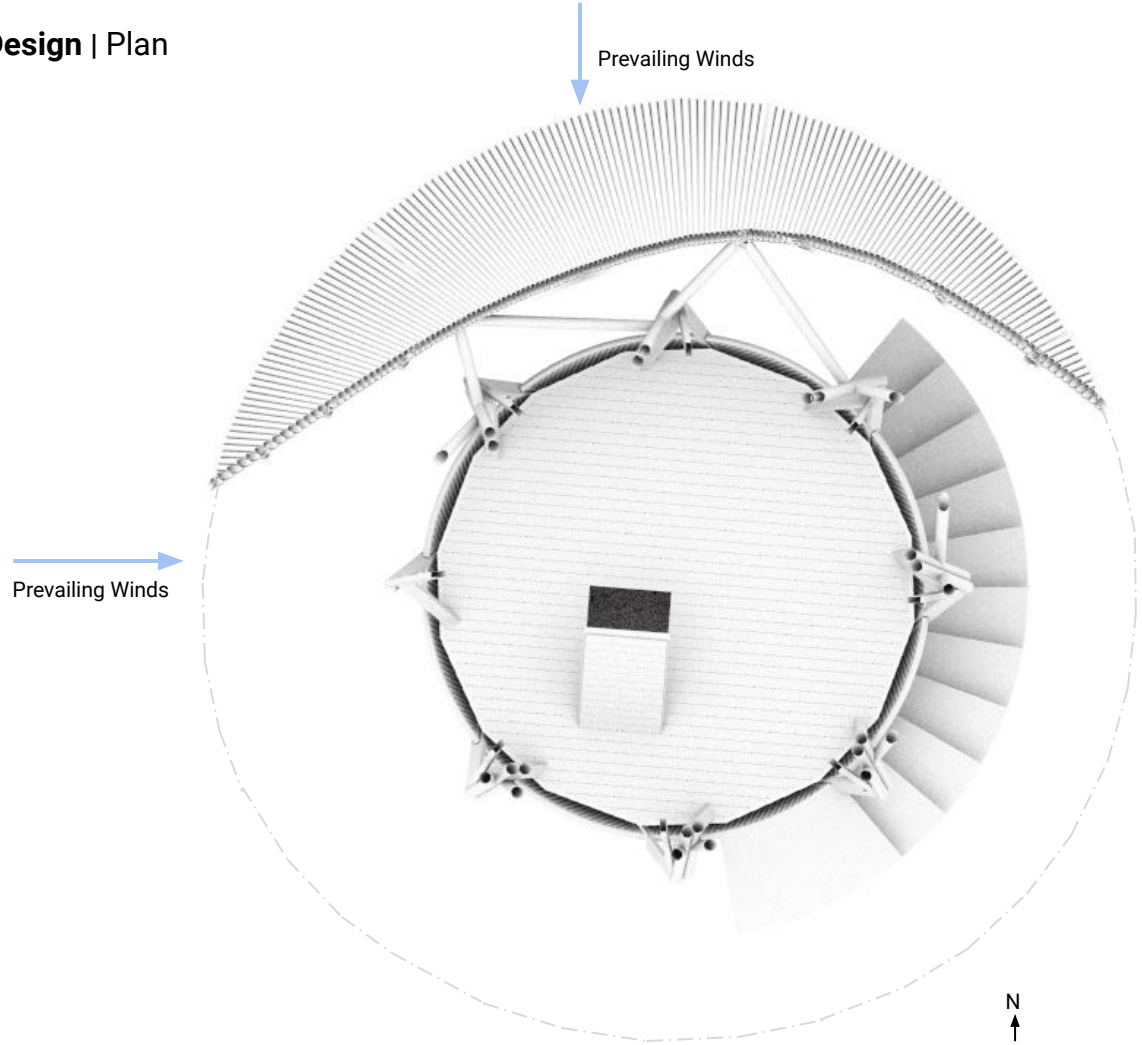
Figure 10: Specimen of nodes and internodes along the culm failed due to radial compression showing different failure modes.

Natural Waterproofing:

https://openbiotecture.wordpress.com/2013/08/12/natural-waterproofing-continued/

1. Gum arabic diluted with ethanol,
2. Liquid silicone,*
3. Liquid silicone diluted with water (1/3),*
4. Black Japan,*
5. Shellac diluted with ethanol,
6. Sal resin diluted with turpentine,
7. Melted shellac,
8. Melted gum arabic,
9. Sealer (commercial product),*
10. Charred bamboo (bamboo "fried" in oil or wax),
11. Bee's wax,
12. Linseed oil overlay,
13. Linseed oil injected with Boucherie pump,
14. Smoked bamboo (consisting in slowly smoking green bamboo over low fire).

Design | Plan



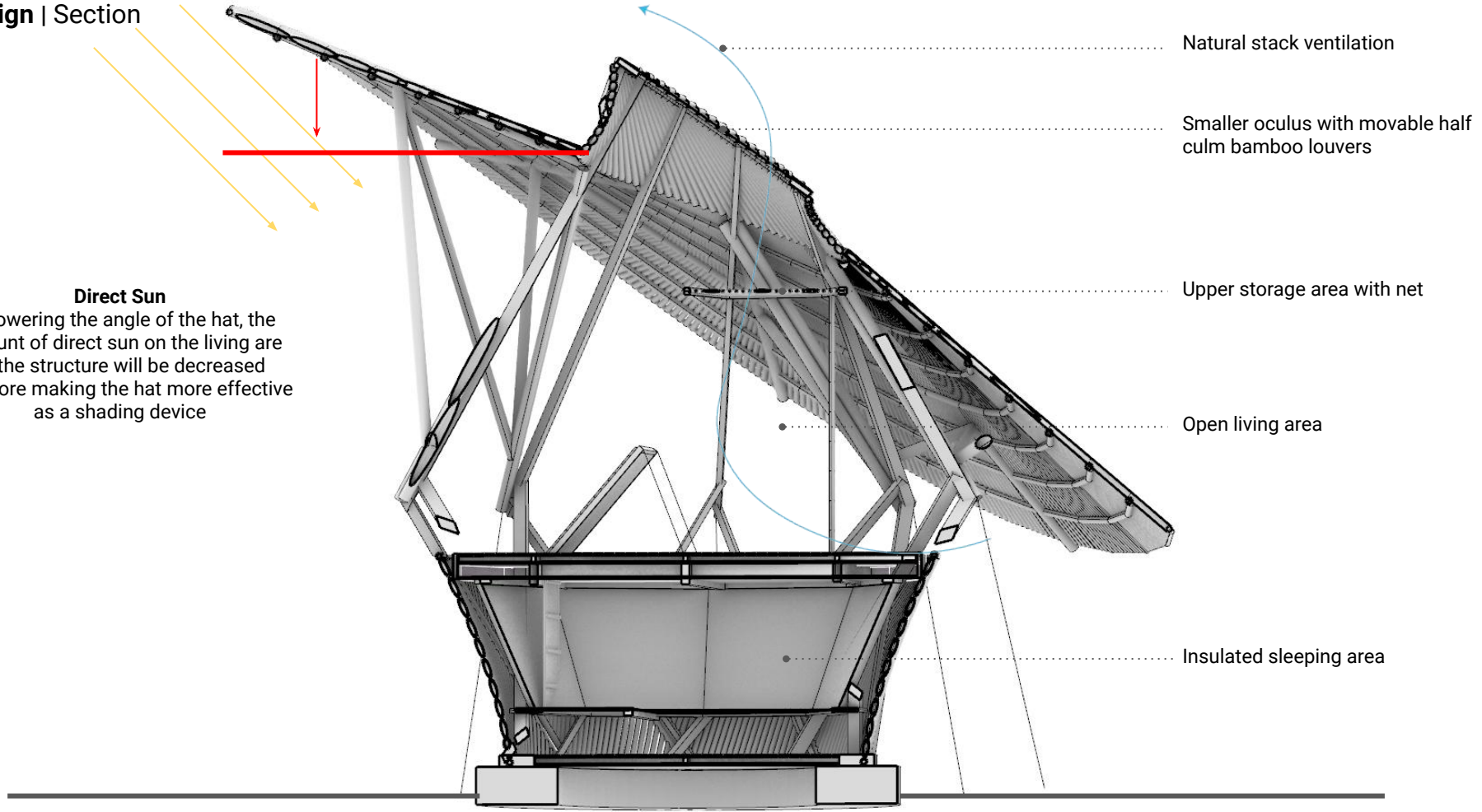
Orientation

- Orientate the structure so that the slant of the oculus always faces North
- This is to reduce the amount of direct sunlight on the oculus
- The ‘sun hat’ will provide a shading and waterproofing layer
- The shading will mostly be for the Southern sun

Skin

- Creating an outer skin layer made from bamboo for solar shading and wind protection

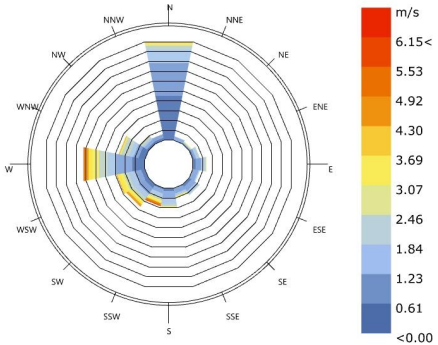
Design | Section



Direct Sun
By lowering the angle of the hat, the amount of direct sun on the living are of the structure will be decreased therefore making the hat more effective as a shading device

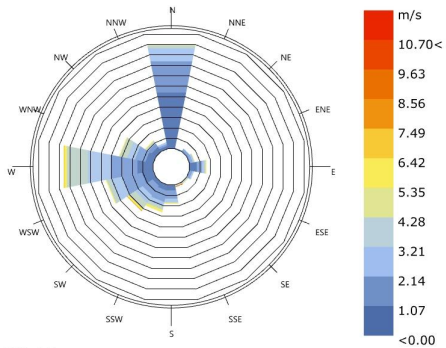
LADYBUG ENVIRONMENTAL ANALYSIS //
KATHMANDU, NEPAL

Ladybug | Seasonal Wind Kathmandu



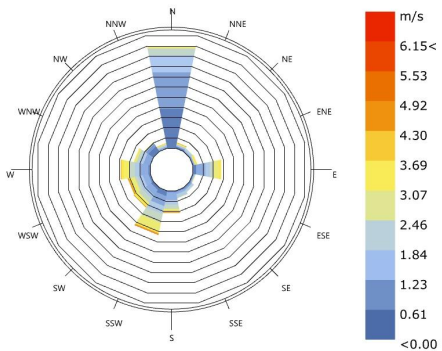
Wind-Rose
KATHMANDU_INTL_ARPT_NPL
1 DEC 1:00 - 28 FEB 24:00
Hourly Data: Wind Speed (m/s)
Calm for 52.08% of the time = 1125 hours.
Each closed polyline shows frequency of 1.3%. = 28 hours.

Winter Wind



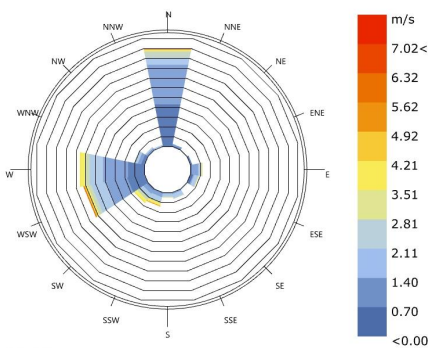
Wind-Rose
KATHMANDU_INTL_ARPT_NPL
1 MAR 1:00 - 31 MAY 24:00
Hourly Data: Wind Speed (m/s)
Calm for 41.17% of the time = 909 hours.
Each closed polyline shows frequency of 1.5%. = 32 hours.

Spring Wind



Wind-Rose
KATHMANDU_INTL_ARPT_NPL
1 JUN 1:00 - 31 AUG 24:00
Hourly Data: Wind Speed (m/s)
Calm for 50.36% of the time = 1112 hours.
Each closed polyline shows frequency of 1.5%. = 33 hours.

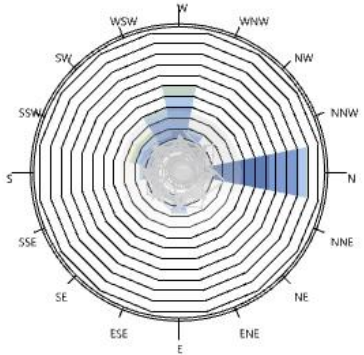
Summer Wind

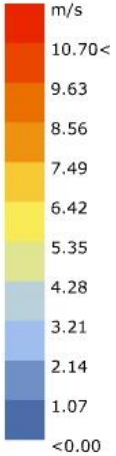


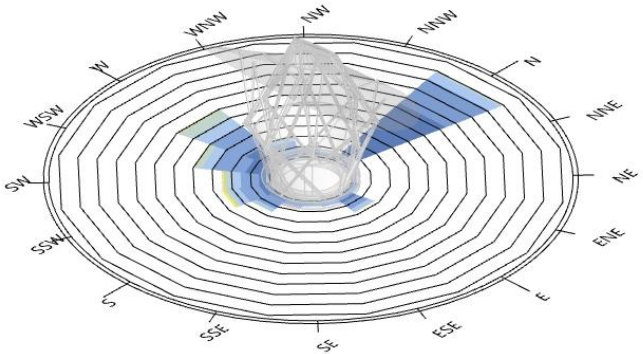
Wind-Rose
KATHMANDU_INTL_ARPT_NPL
1 SEP 1:00 - 30 NOV 24:00
Hourly Data: Wind Speed (m/s)
Calm for 54.40% of the time = 1188 hours.
Each closed polyline shows frequency of 1.4%. = 31 hours.

Autumn Wind

Ladybug | Yearly Wind Kathmandu





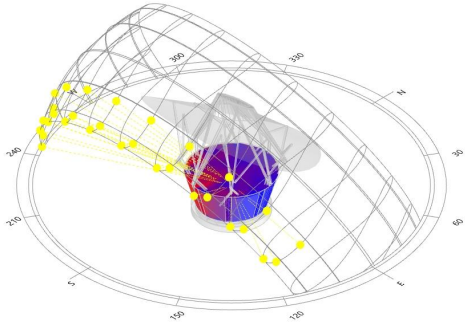


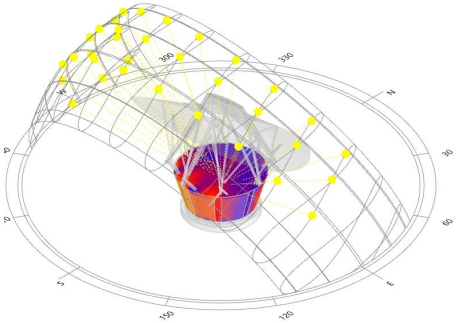
Wind-Rose
KATHMANDU_INTL_ARPT_NPL
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 49.47% of the time = 4334 hours.
Each closed polyline shows frequency of 1.4%. = 126 hours.

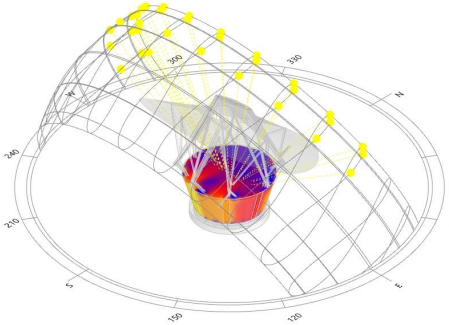
Northern / Western Winds
This shows that the anchoring of the hat on the Northern part of the structure will decrease the chances of uplift

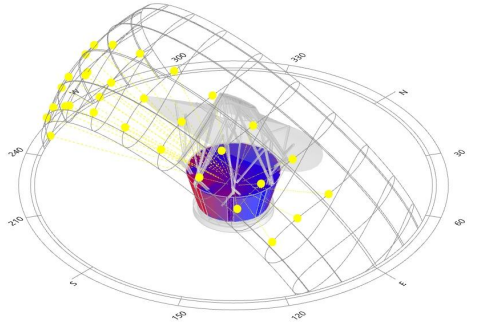
Ladybug | Solar Hours // Bottom Area // Kathmandu

To accommodate for sunlight exposure:
The hat angle should be lowered on the southern side of the structure to reduce the amount of sunlight hours on the bottom area of the structure

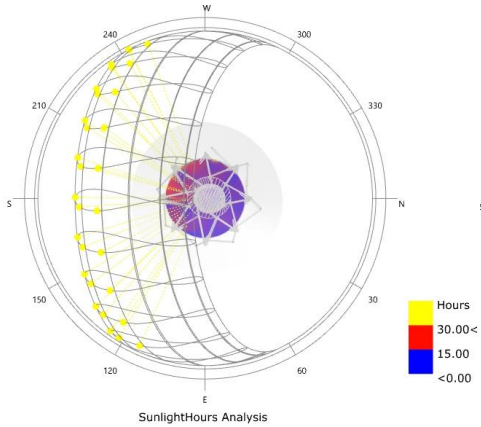




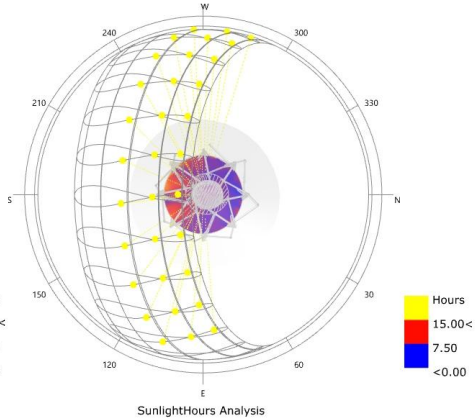




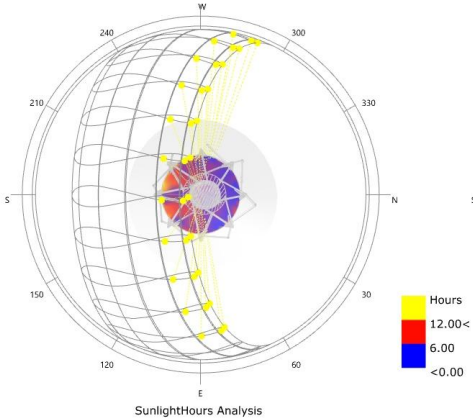
Winter Sunlight Hours



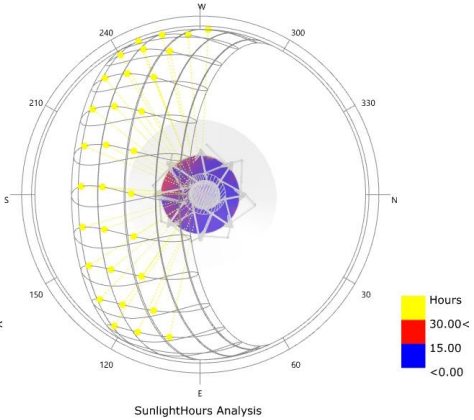
Spring Sunlight Hours

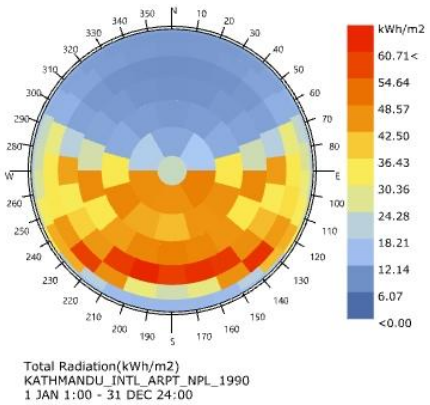


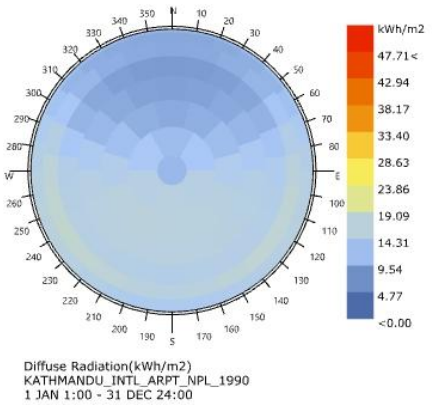
Summer Sunlight Hours

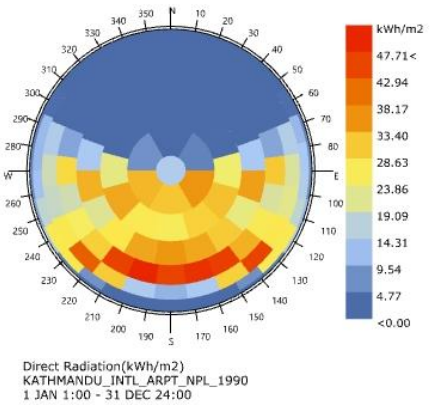


Autumn Sunlight Hour

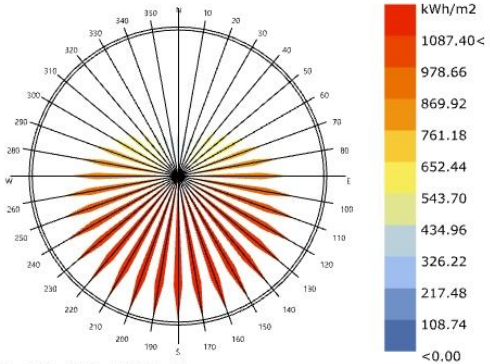




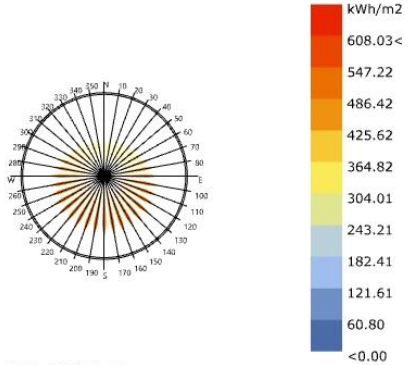




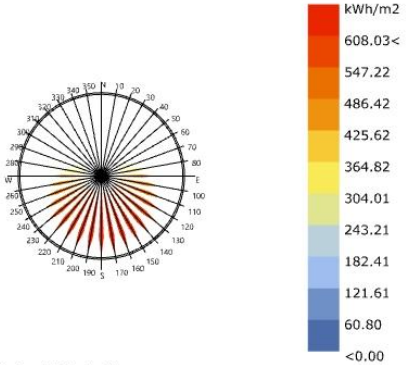
Radiation from the South:
This shows that the orientation of the structure is crucial. Facing the structure south (with the oculus facing North) reduces the chances of direct sunlight on the oculus. The hat that faces south will shade from the southern sun.



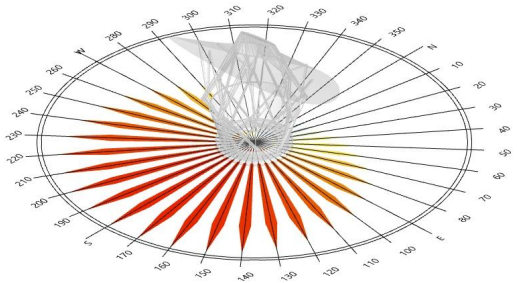
Total Radiation(kWh/m2)
KATHMANDU_INTL_ARPT_NPL_1990
1 JAN 1:00 - 31 DEC 24:00



Diffuse Radiation(kWh/m2)
KATHMANDU_INTL_ARPT_NPL_1990
1 JAN 1:00 - 31 DEC 24:00



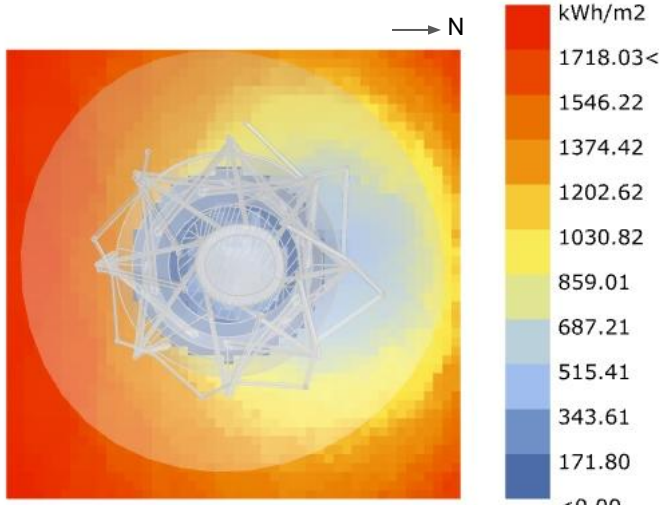
Direct Radiation(kWh/m2)
KATHMANDU_INTL_ARPT_NPL_1990
1 JAN 1:00 - 31 DEC 24:00



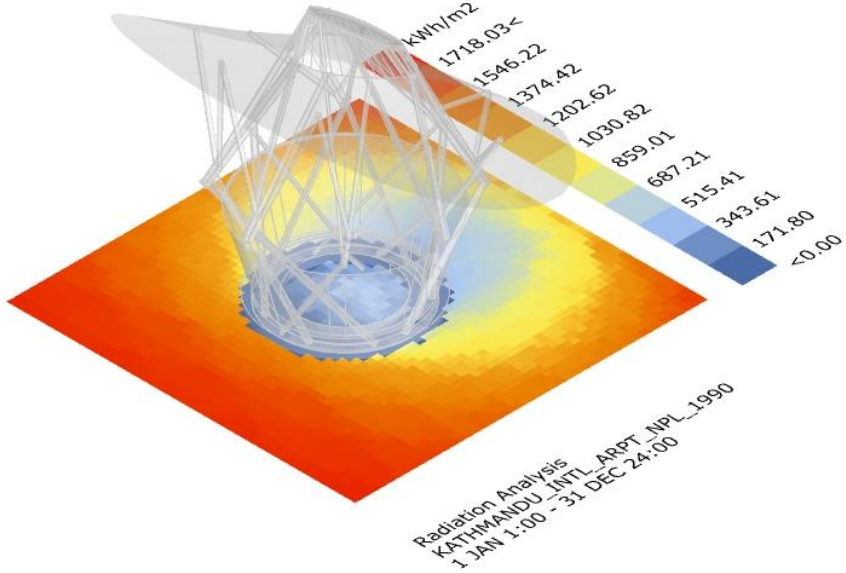
Radiation from the South:
This shows that the orientation of the structure is crucial. Facing the structure south (with the oculus facing North) reduces the chances of direct sunlight on the oculus. The hat that faces south will shade from the southern sun.

Ladybug | Radiation Analysis Structure Kathmandu

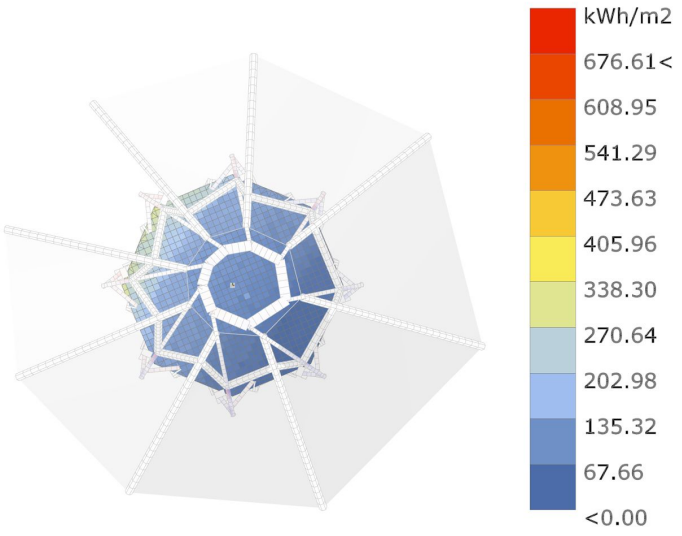
Radiation from the South:
This shows that the orientation of the structure is crucial. Facing the structure south (with the oculus facing North) reduces the chances of direct sunlight on the oculus. The hat that faces south will shade from the southern sun.



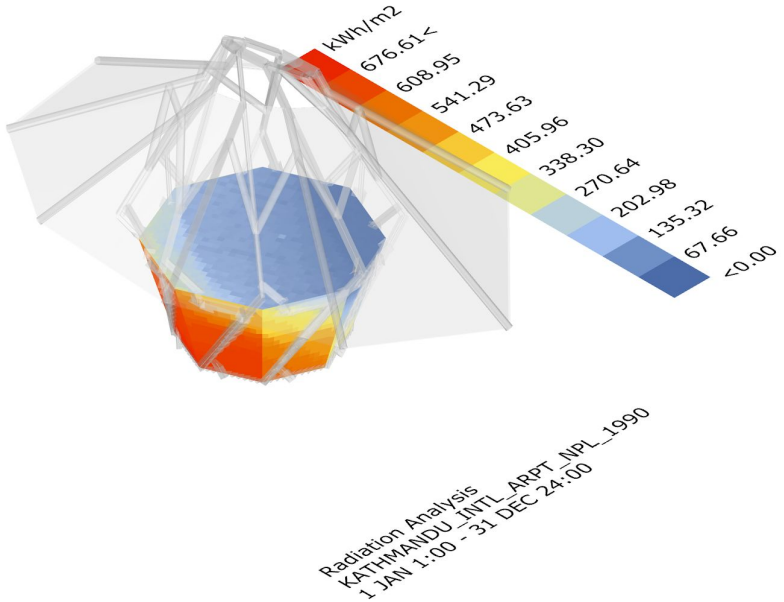
Radiation Analysis
KATHMANDU_INTL_ARPT_NPL_1990
1 JAN 1:00 - 31 DEC 24:00



Ladybug | Radiation Analysis Bottom Area Kathmandu

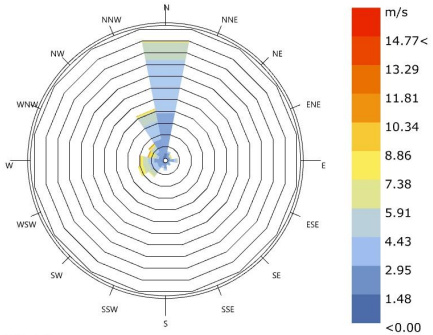


Radiation Analysis
KATHMANDU_INTL_ARPT_NPL_1990
1 JAN 1:00 - 31 DEC 24:00



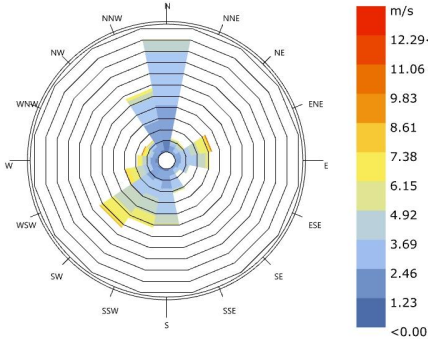
LADYBUG ENVIRONMENTAL ANALYSIS //
BARCELONA, SPAIN

Ladybug | Seasonal Wind Barcelona



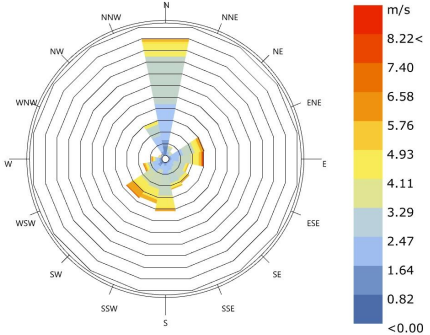
Wind-Rose
BARCELONA_ESP
1 DEC 1:00 - 28 FEB 24:00
Hourly Data: Wind Speed (m/s)
Calm for 9.77% of the time = 211 hours.
Each closed polyline shows frequency of 3.3%. = 71 hours.

Winter Wind



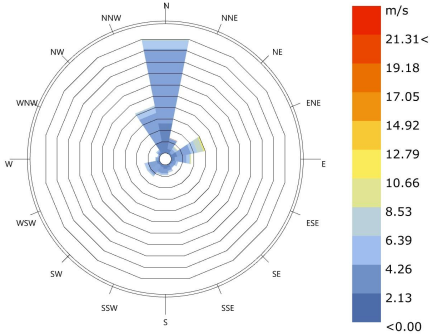
Wind-Rose
BARCELONA_ESP
1 MAR 1:00 - 31 MAY 24:00
Hourly Data: Wind Speed (m/s)
Calm for 18.43% of the time = 407 hours.
Each closed polyline shows frequency of 1.5%. = 34 hours.

Spring Wind



Wind-Rose
BARCELONA_ESP
1 JUN 1:00 - 31 AUG 24:00
Hourly Data: Wind Speed (m/s)
Calm for 10.33% of the time = 228 hours.
Each closed polyline shows frequency of 2.2%. = 48 hours.

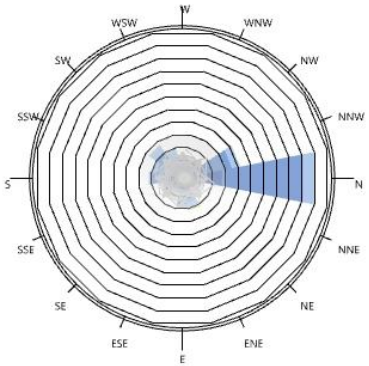
Summer Wind

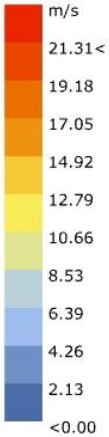


Wind-Rose
BARCELONA_ESP
1 SEP 1:00 - 30 NOV 24:00

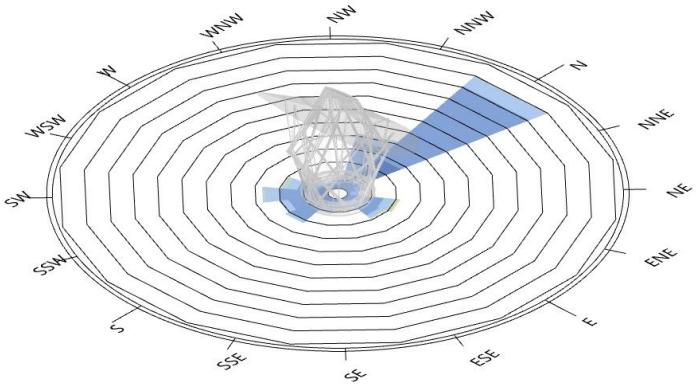
Autumn Wind

Ladybug | Yearly Wind Barcelona





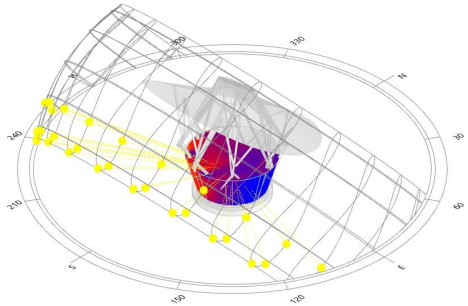
Wind-Rose
BARCELONA_ESP
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 15.29% of the time = 1339 hours.
Each closed polyline shows frequency of 2.4%. = 213 hours.

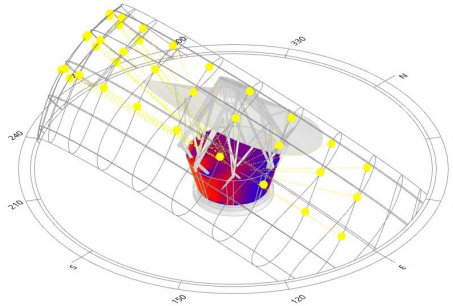


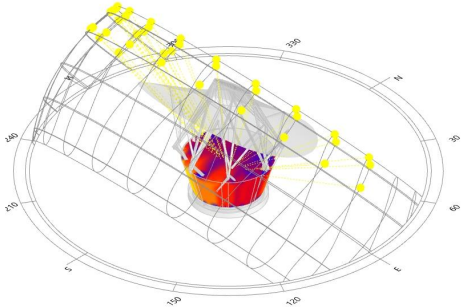
Northern Winds
This shows that the anchoring of the hat on the Northern part of the structure will decrease the chances of uplift

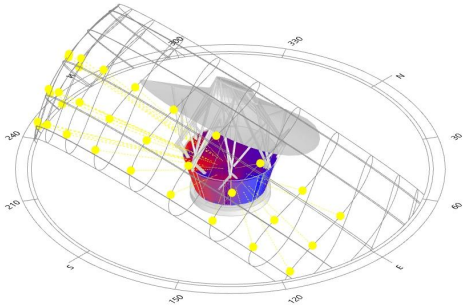
Ladybug | Solar Hours // Bottom Area // Barcelona

To accommodate for sunlight exposure:
The hat angle should be lowered on the southern side of the structure to reduce the amount of sunlight hours on the bottom area of the structure

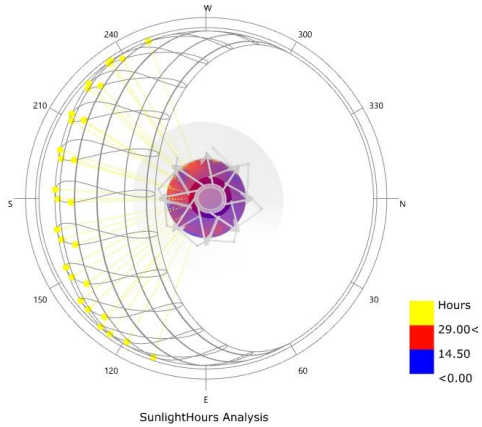




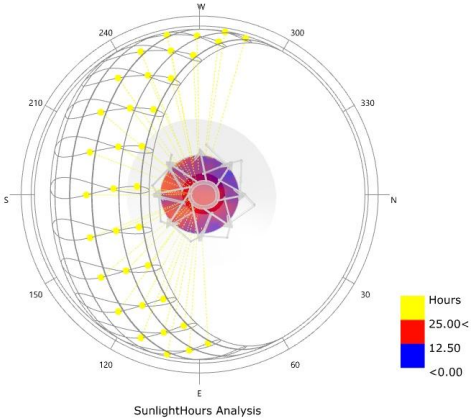




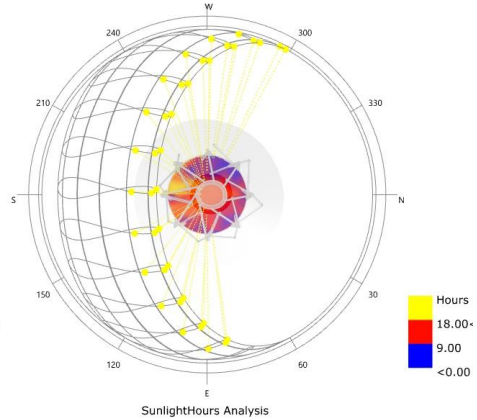
Winter Sunlight Hours



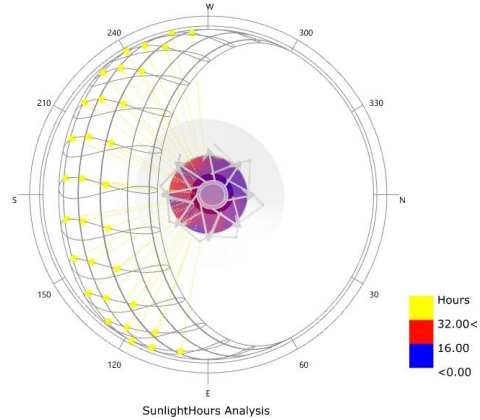
Spring Sunlight Hours

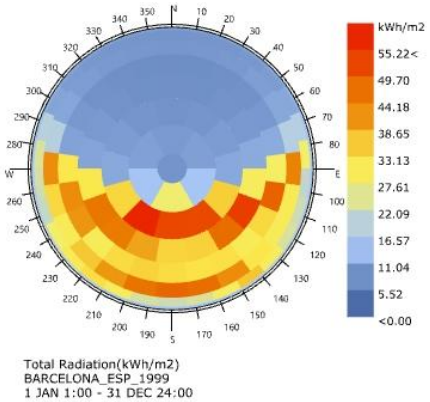


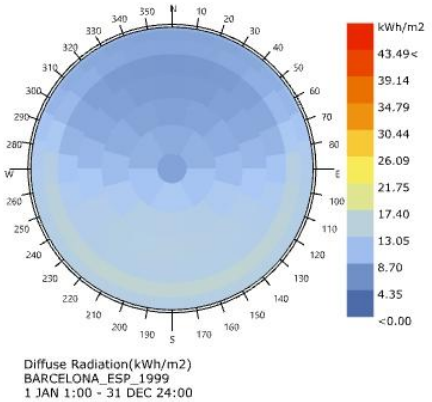
Summer Sunlight Hours

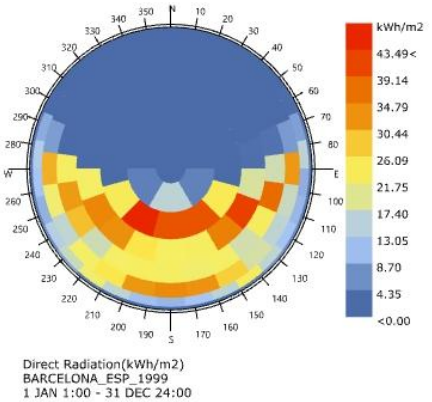


Autumn Sunlight Hour

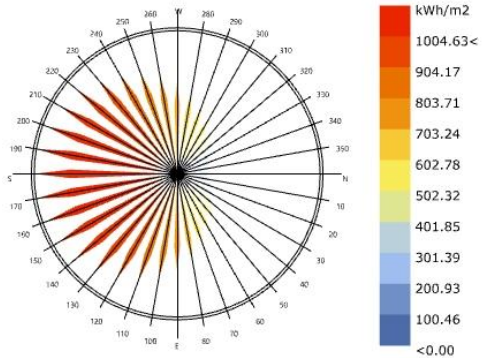




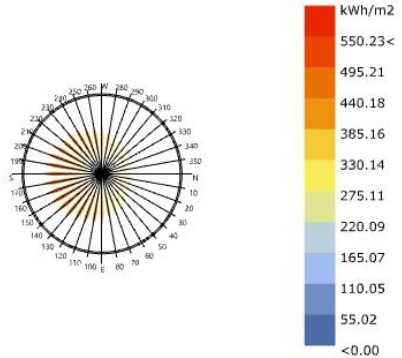




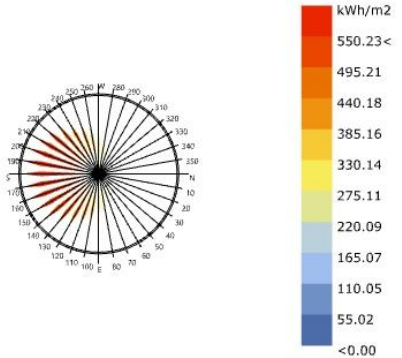
Radiation from the South:
This shows that the orientation of the structure is crucial. Facing the structure south (with the oculus facing North) reduces the chances of direct sunlight on the oculus. The hat that faces south will shade from the southern sun.



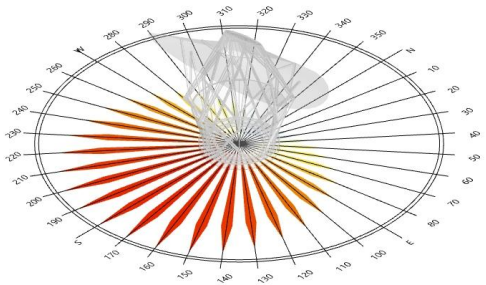
Total Radiation(kWh/m2)
BARCELONA_ESP_1999
1 JAN 1:00 - 31 DEC 24:00



Diffuse Radiation(kWh/m2)
BARCELONA_ESP_1999
1 JAN 1:00 - 31 DEC 24:00



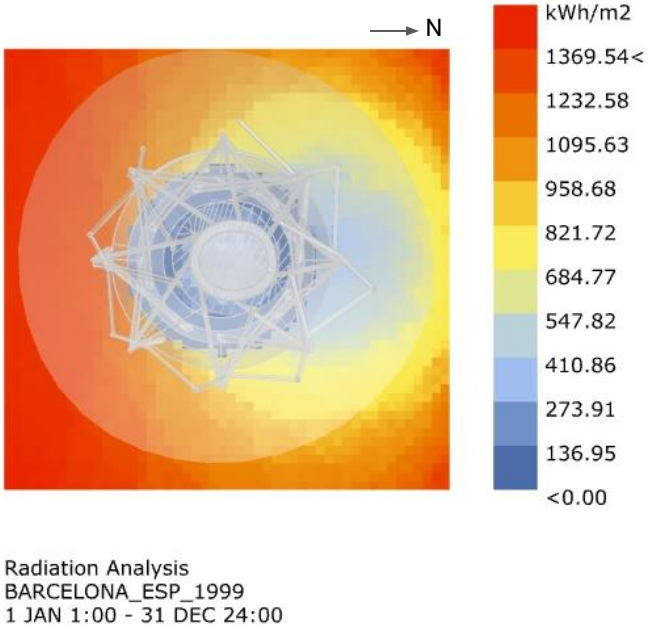
Direct Radiation(kWh/m2)
BARCELONA_ESP_1999
1 JAN 1:00 - 31 DEC 24:00

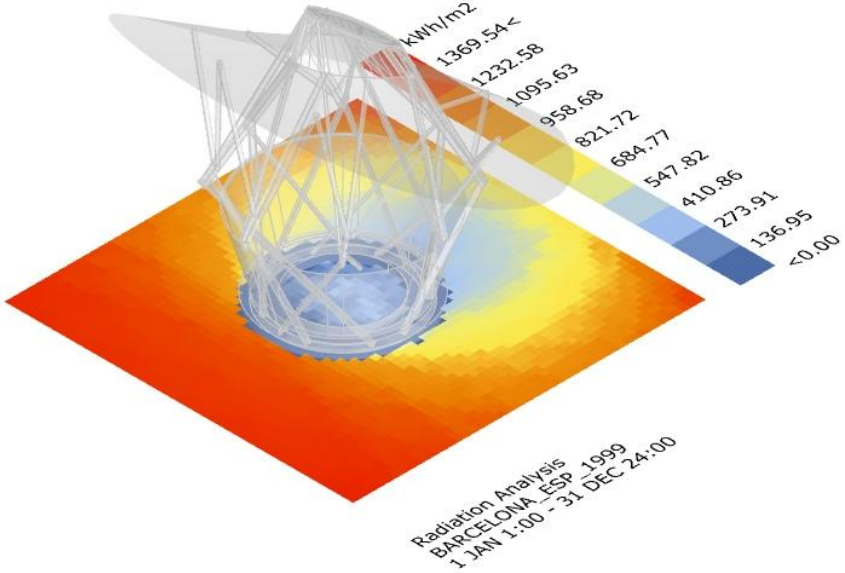


Radiation from the South:
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Ladybug | Radiation Analysis Barcelona

Radiation from the South:
This shows that the orientation of the structure is crucial. Facing the structure south (with the oculus facing North) reduces the chances of direct sunlight on the oculus. The hat that faces south will shade from the southern sun.

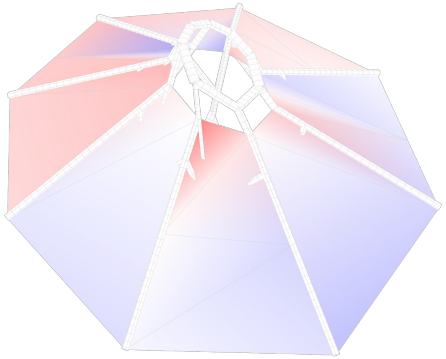


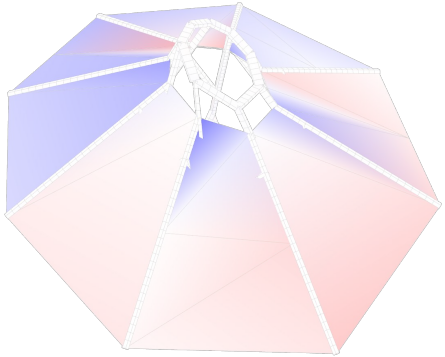


KARAMBA STRUCTURAL ANALYSIS // SHELL
ANALYSIS AND STRUCTURAL LOADS

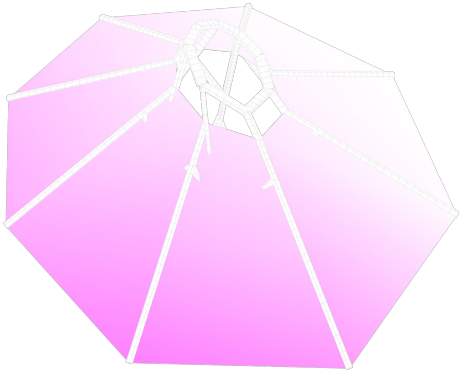
Karamba | Shell Analysis

utilization
-0.3%
-0.2%
-0.2%
-0.2%
-0.1%
-0.1%
-0.1%
0.0%
0.0%
0.0%
0.1%
0.1%
0.1%
0.1%
0.2%
0.2%
0.2%



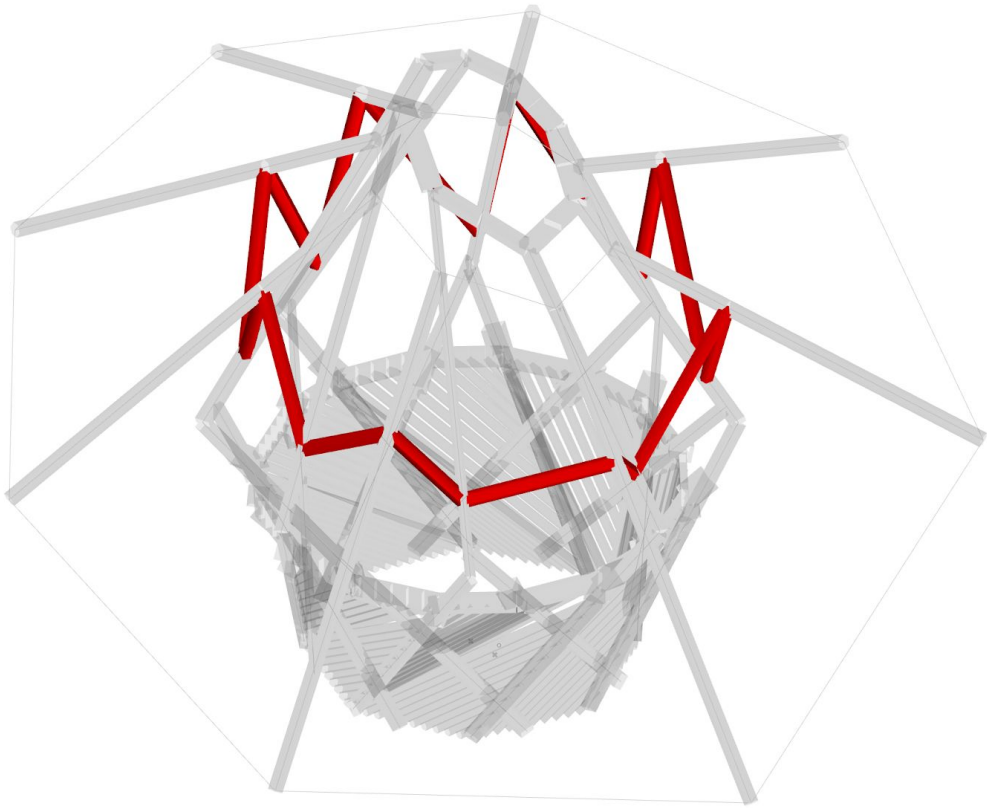


res.disp.[cm]
8.51e-01
9.63e-01
1.07e+00
1.19e+00
1.30e+00
1.41e+00
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1.63e+00
1.74e+00
1.86e+00
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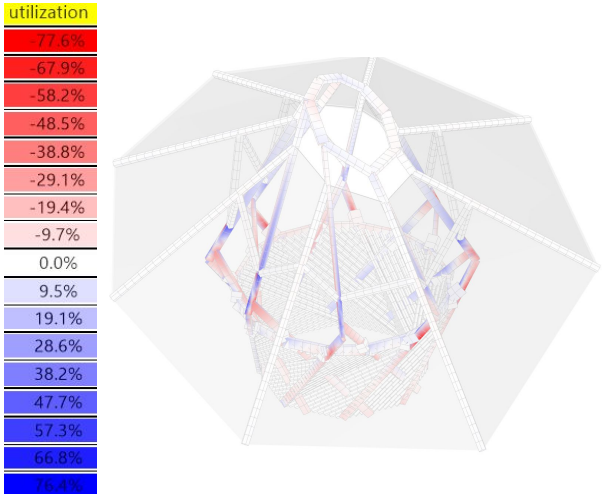


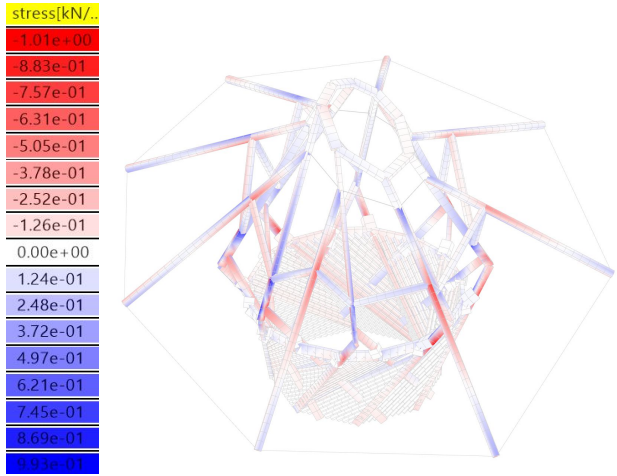
Karamba | Analysed Structure // Bamboo Bracing 01

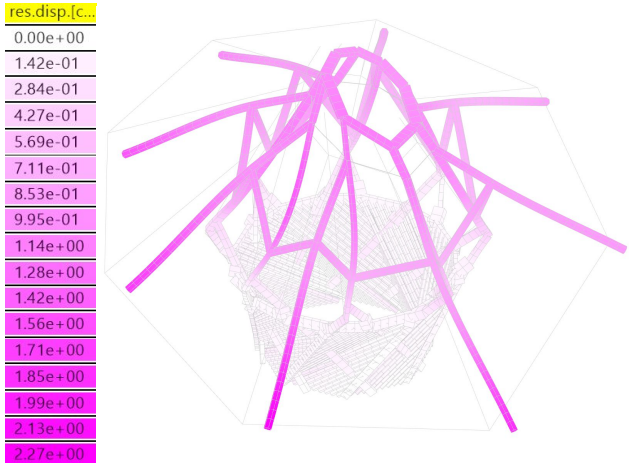
Possible Bamboo Bracing for Shading Hat:
In order to utilize the bamboo's strength and use the least amount of material as possible, we explored various ways of how to brace the lightweight timber shading hat

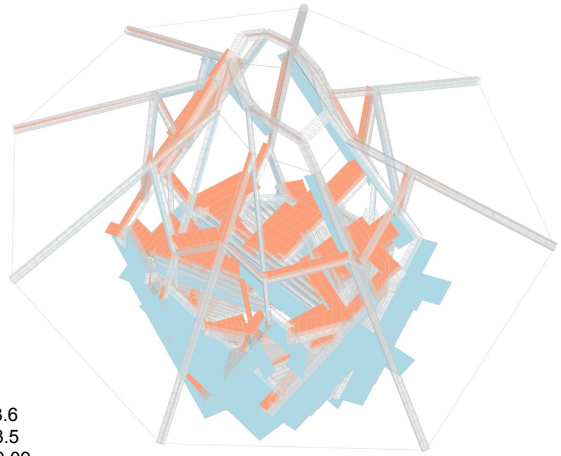


Karamba | Analysed Structure // Bamboo Bracing 01 // Roof Wind Load

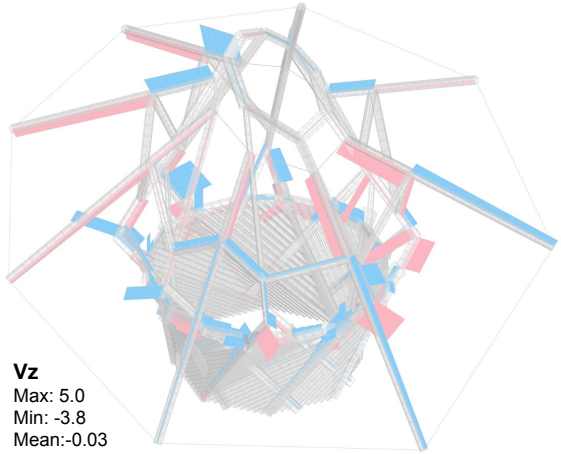




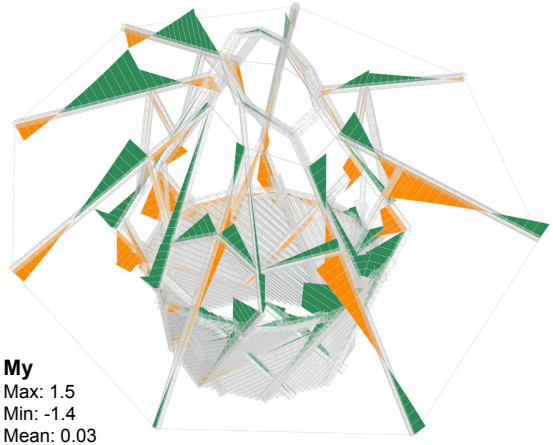




Nx
Max: 13.6
Min: -13.5
Mean:-0.09



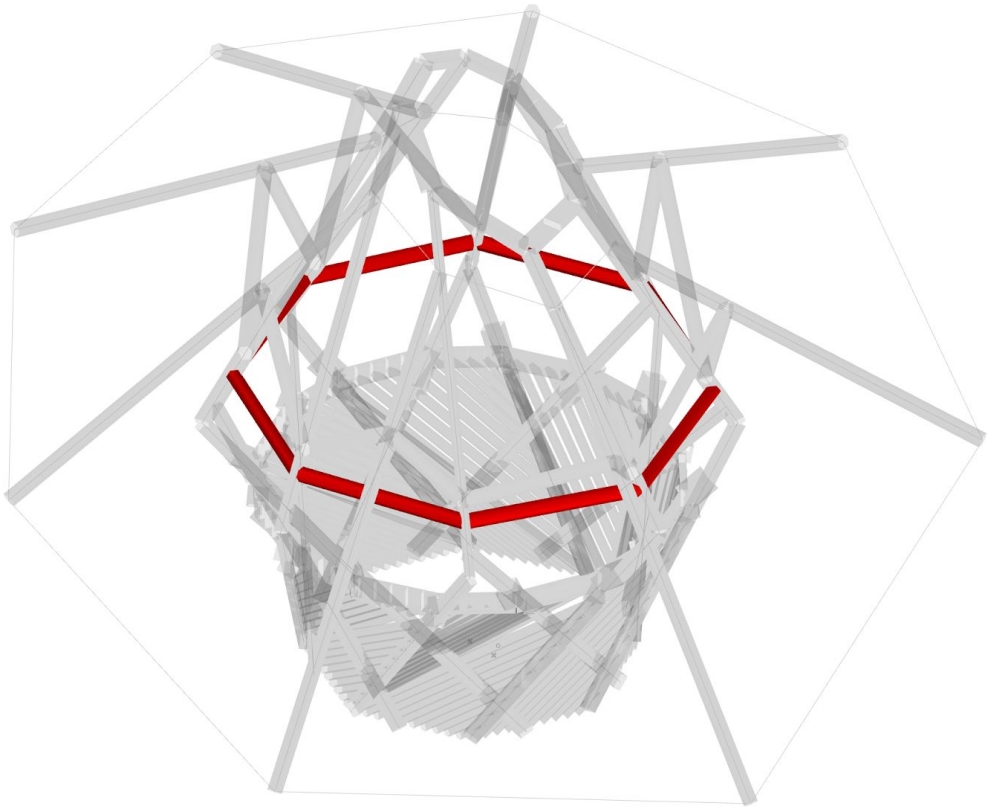
Vz
Max: 5.0
Min: -3.8
Mean:-0.03



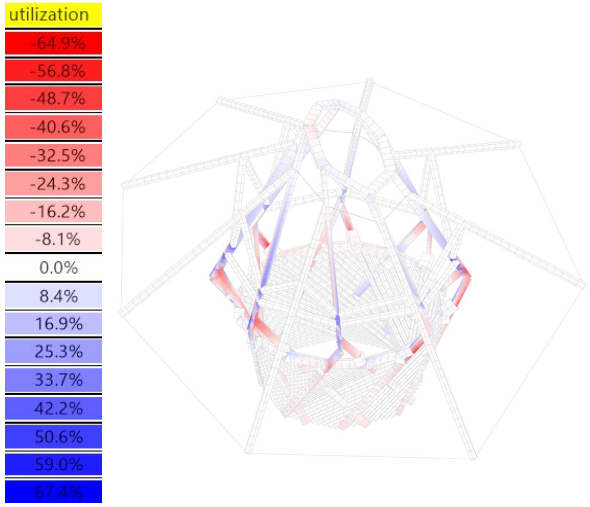
My
Max: 1.5
Min: -1.4
Mean: 0.03

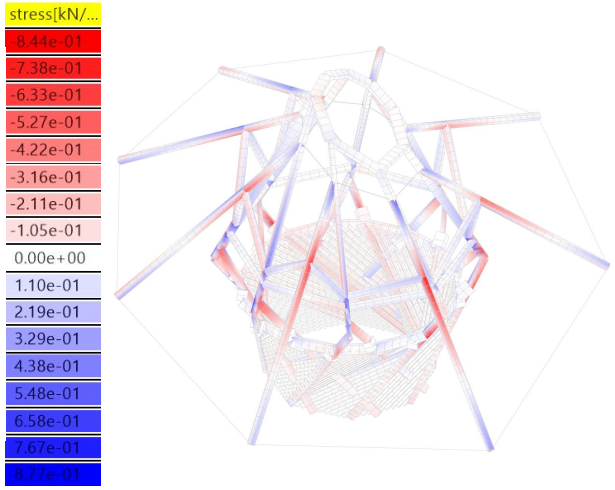
Karamba | Analysed Structure // Bamboo Bracing 02

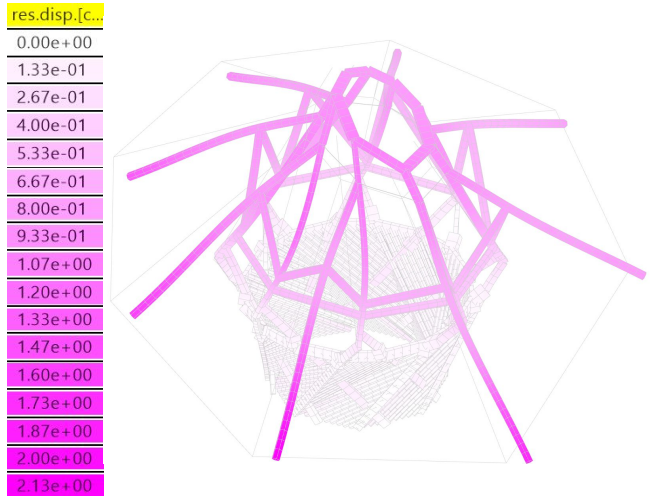
Possible Bamboo Bracing for Shading Hat:
In order to utilize the bamboo's strength and use the least amount of material as possible, we explored various ways of how to brace the lightweight timber shading hat

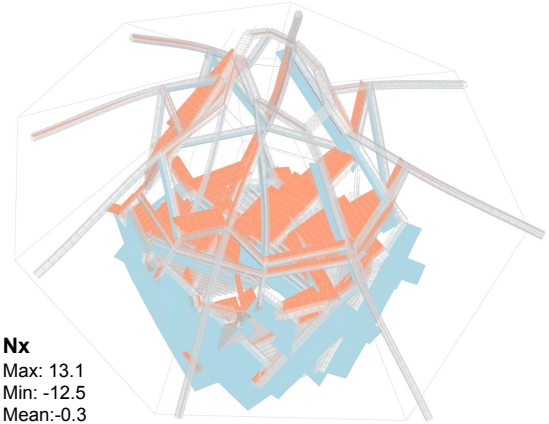


Karamba | Analysed Structure // Bamboo Bracing 02

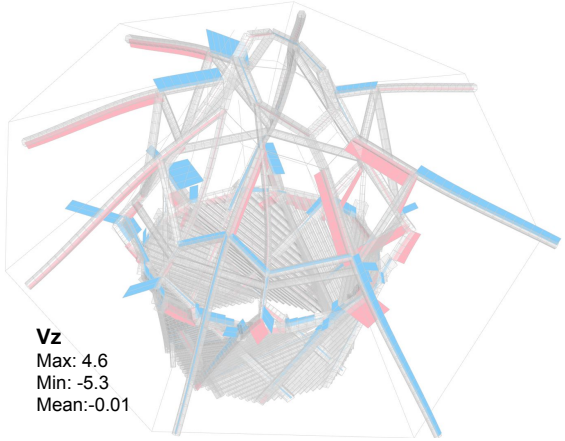




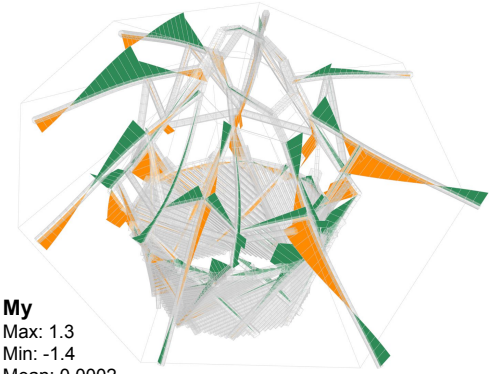




Nx
Max: 13.1
Min: -12.5
Mean:-0.3



Vz
Max: 4.6
Min: -5.3
Mean:-0.01

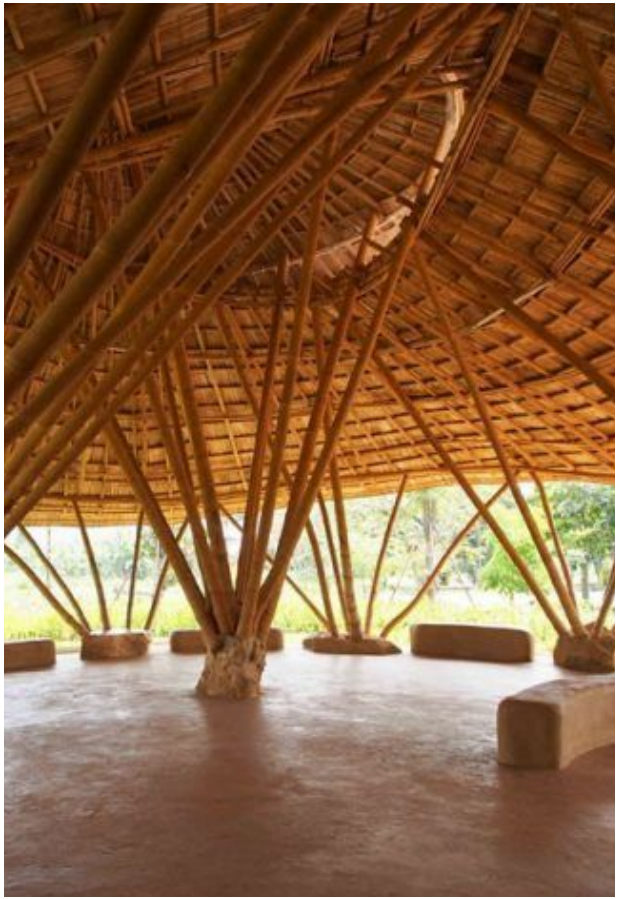


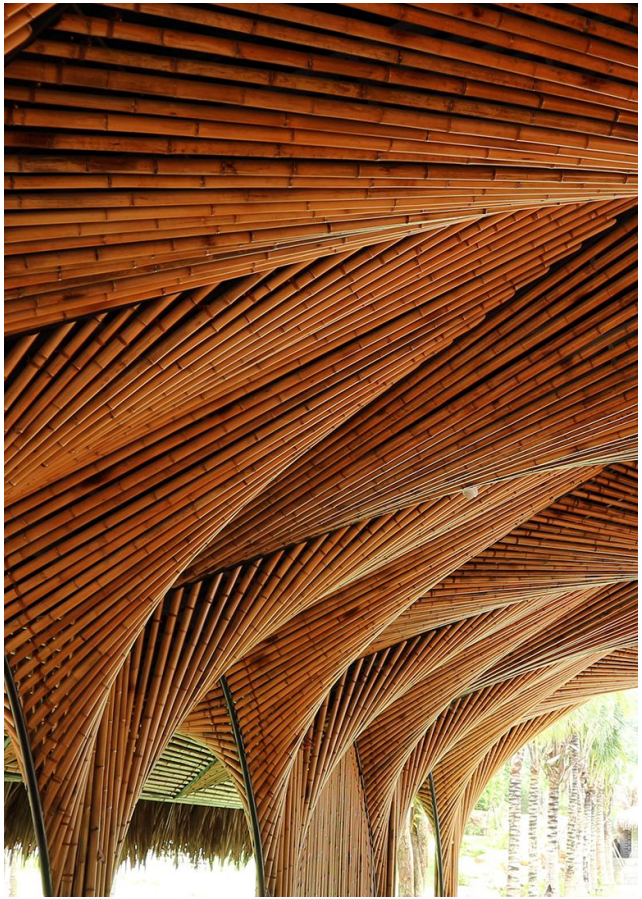
My
Max: 1.3
Min: -1.4
Mean: 0.0002

Precedent Construction Details | Roof Structure



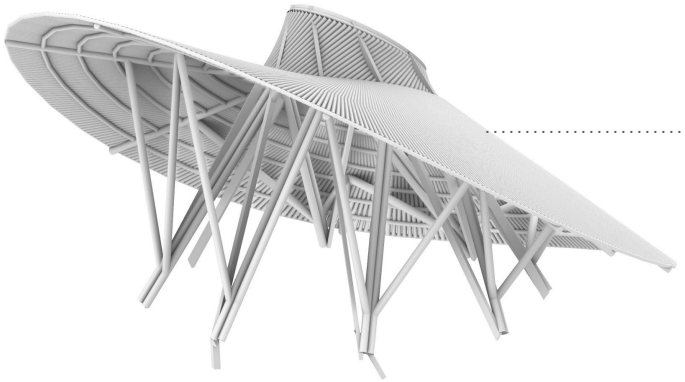
Swirling Cloud - SUP Atelier
https://www.archdaily.com/913836/swirling-cloud-bulletin-pavilion-for-bjfu-garden-festival-sup-atelier/5c98315b284dd1fbf30001d3-swirling-cloud-bulletin-pavilion-for-bjfu-garden-festival-sup-atelier-photo?next_project=no

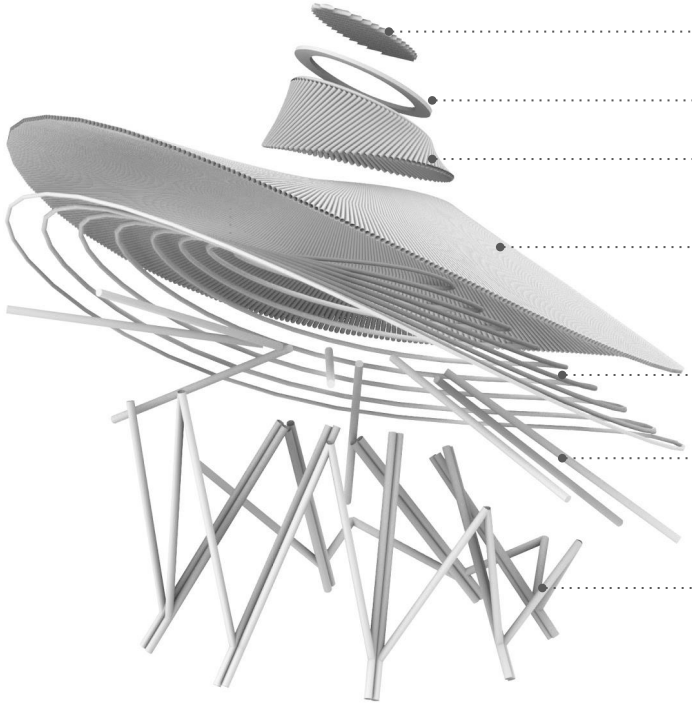




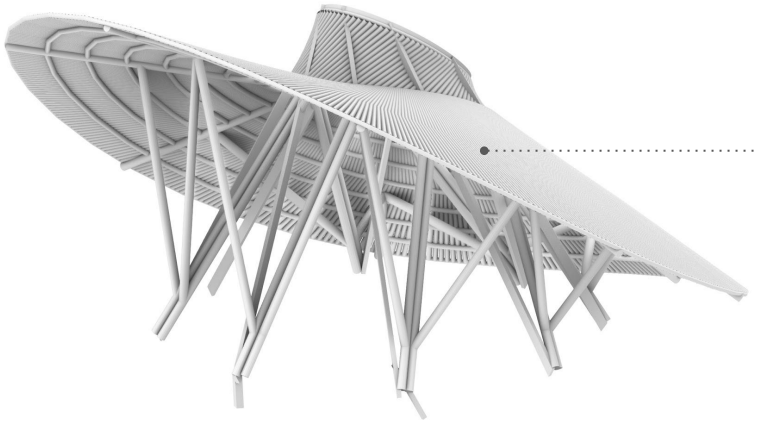
Roof Design | Exploded Axo

Shading Hat:
The original ribs and oculus are made of timber
The whole shading hat is made of bamboo

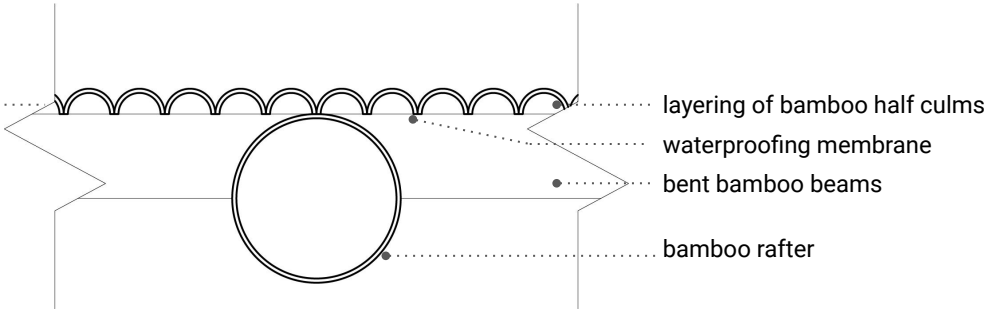




Construction Details | Roof Structure - Layered Bamboo



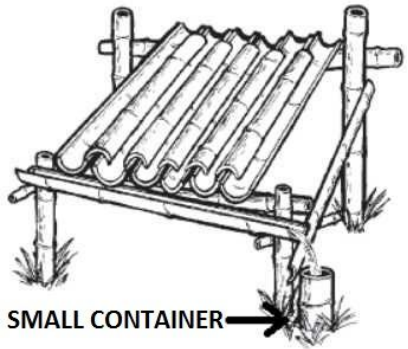
SECTION OF BAMBOO ROOF STRUCTURE





Swirling Cloud: Bulletin Pavilion for BJFU Garden Festival // SUP Atelier // China





Ideas for water harvesting 'gutter' on roof structure

Construction Details | Bamboo Connection for Roof Supports // Fishmouth Joinery & Double Element









https://www.echocommunity.org/resources/ff7fbabb-149c-4e34-9c8c-12dd558859f2

https://bamboou.com/projects/fishy-joinery/

Construction Details | Bamboo connection

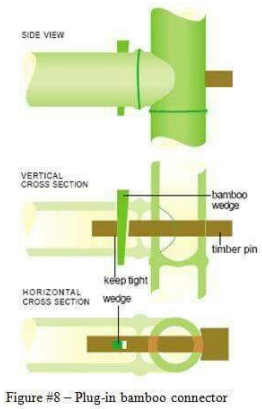
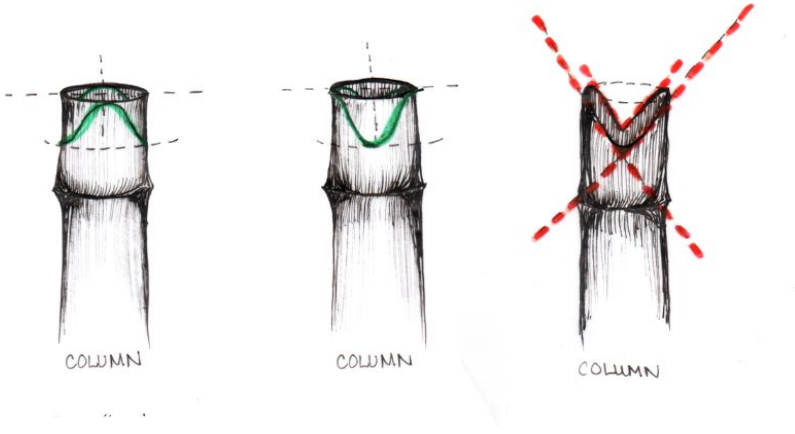
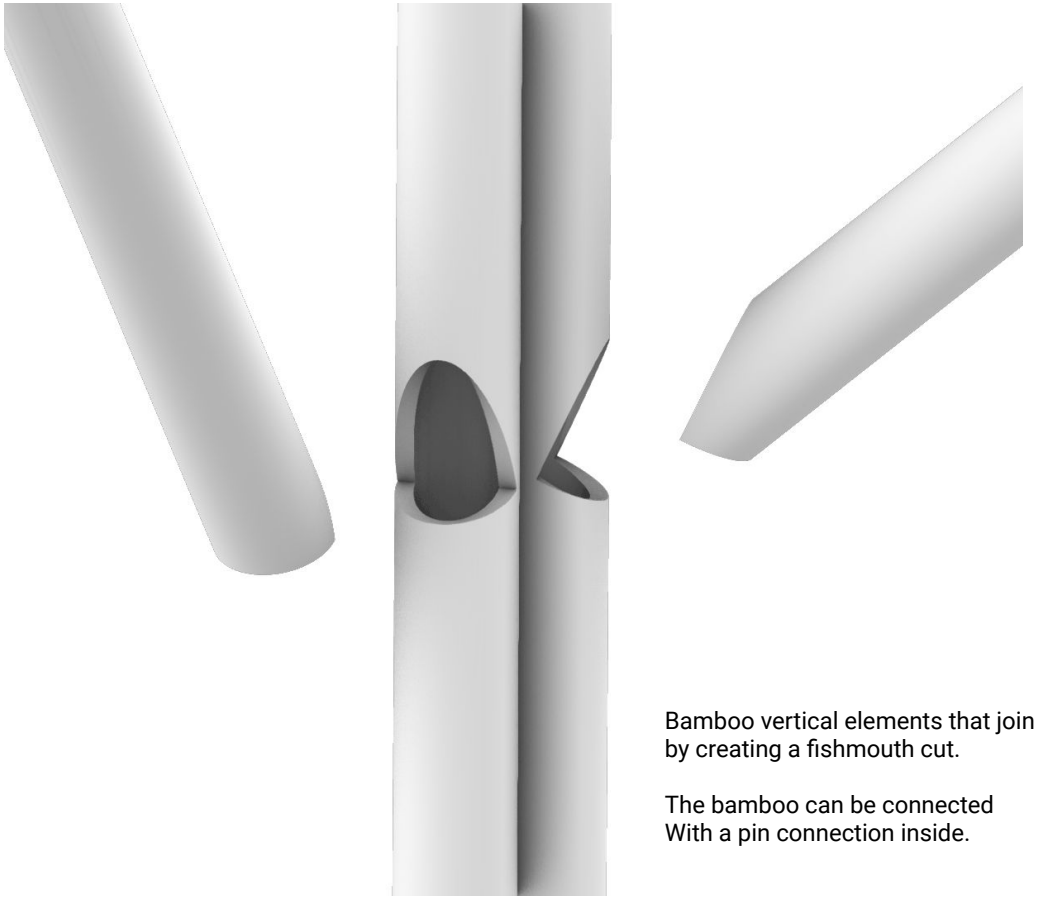


Figure #8 – Plug-in bamboo connector



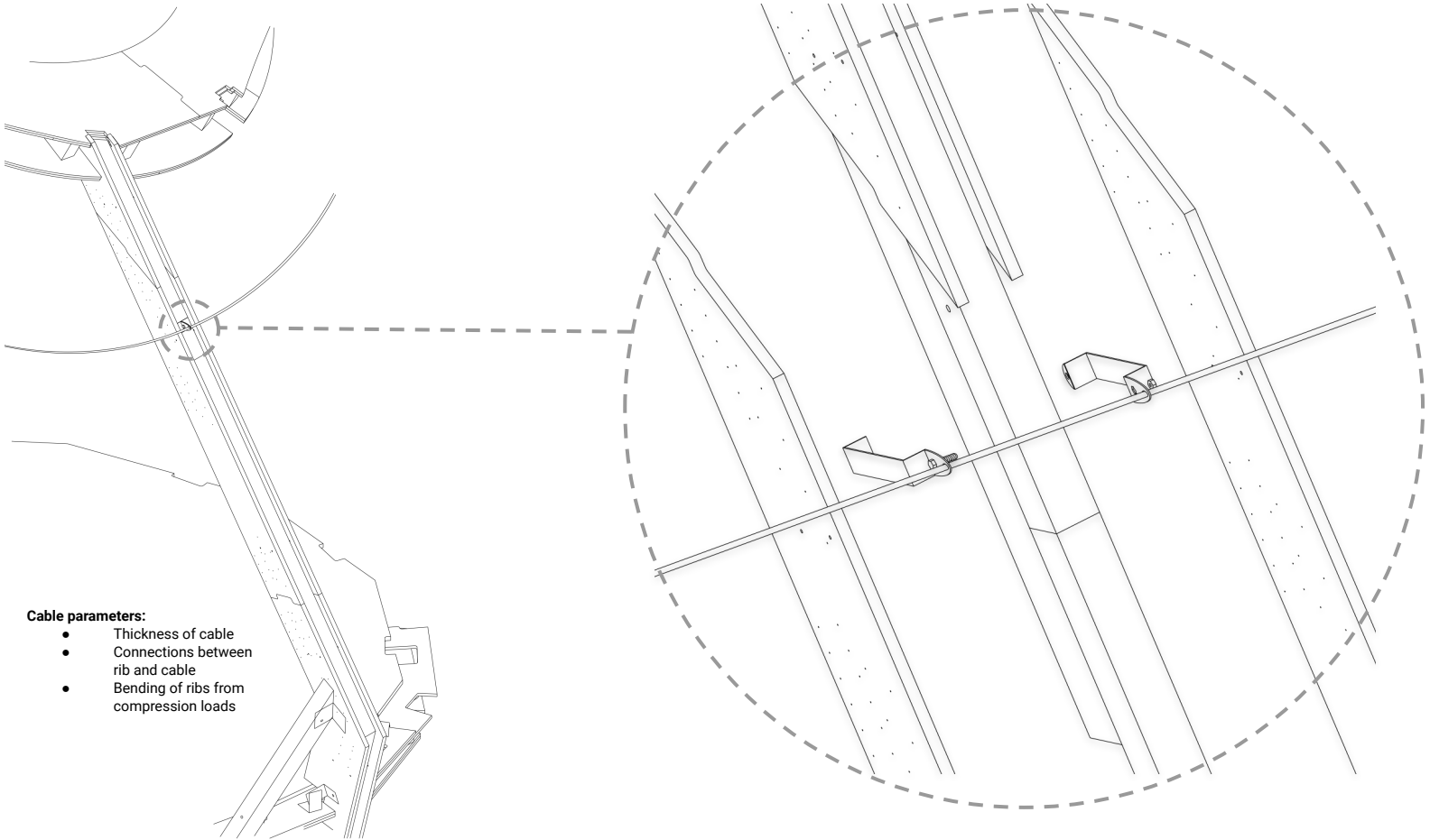




Bamboo vertical elements that join by creating a fishmouth cut.

The bamboo can be connected With a pin connection inside.

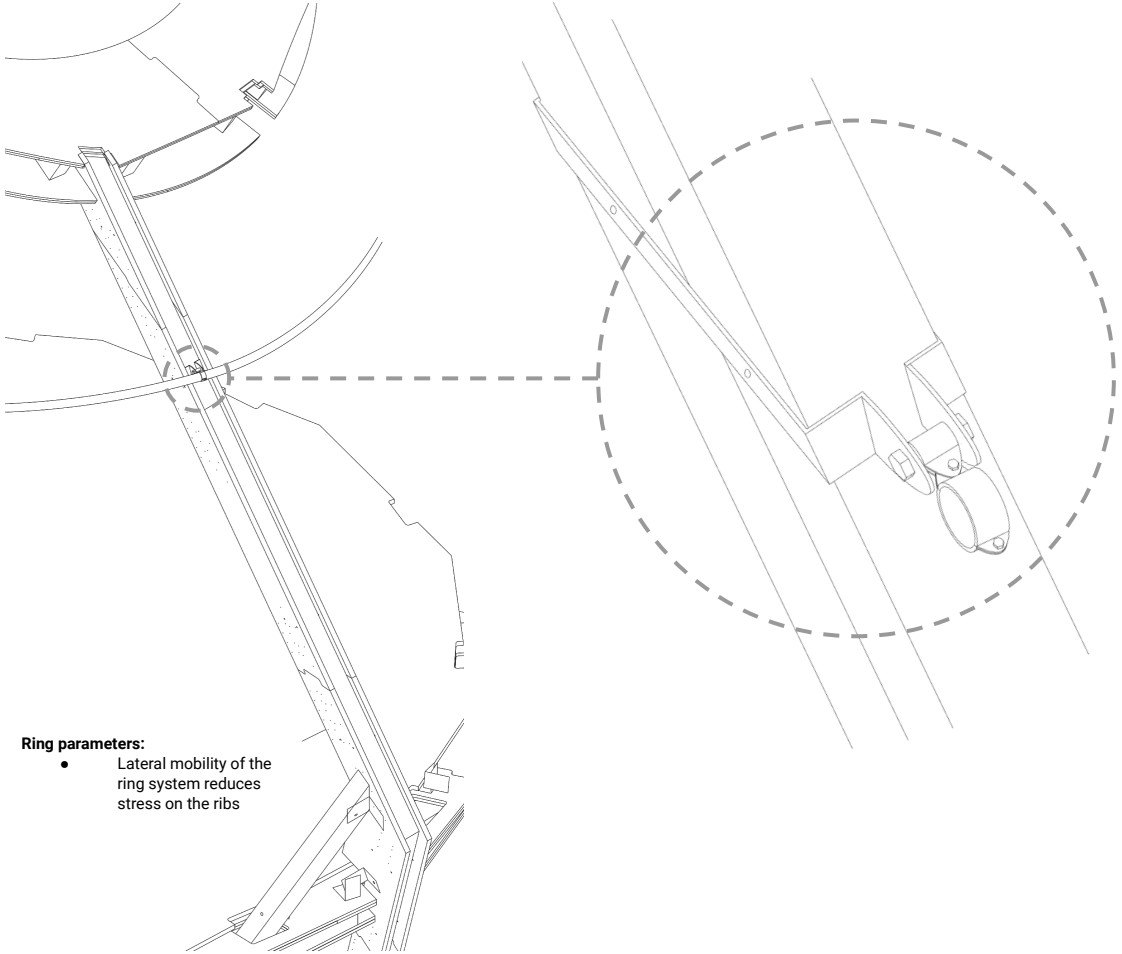
Construction Details | Roof Structure // Cable

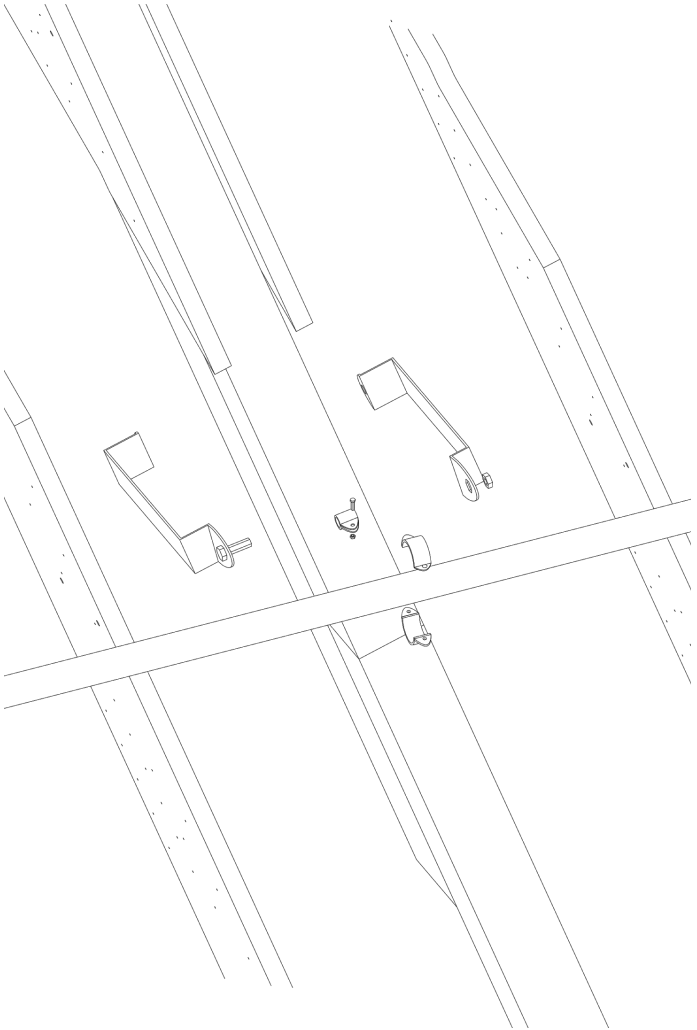


Cable parameters:

- Thickness of cable
- Connections between rib and cable
- Bending of ribs from compression loads

Construction Details | Roof Structure - Bamboo Ring

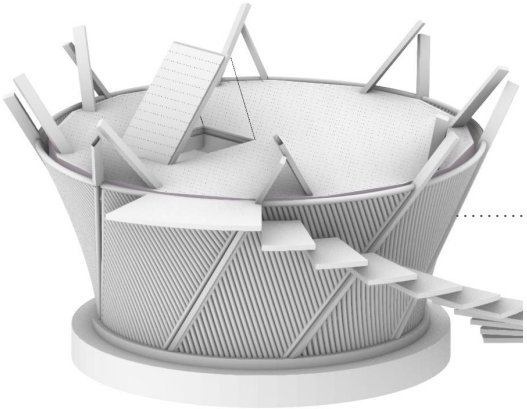


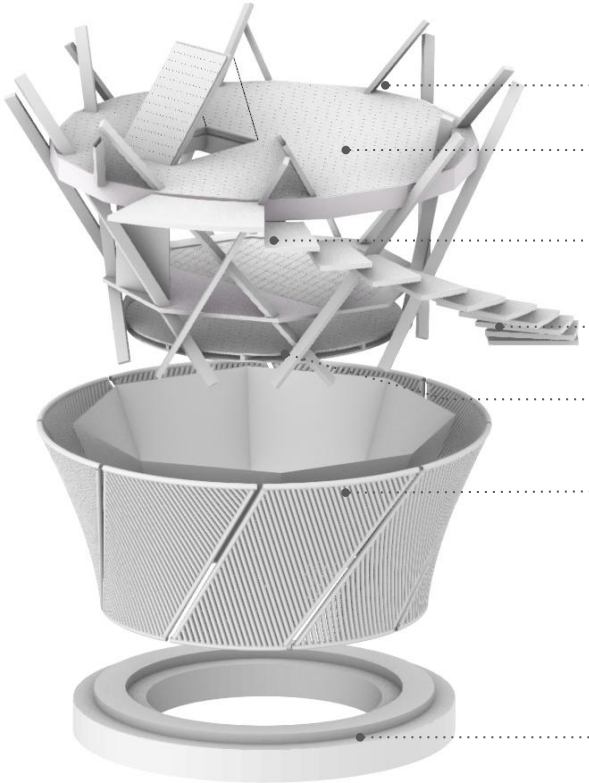


Ring parameters:

- Lateral mobility of the ring system reduces stress on the ribs

Bottom Structure | Exploded Axo





Original slanted timber ribs

Waterproof slanted timber floor with opening for access to sleeping area

Sleeping area (with platform and net) - sleeps up to 4 people

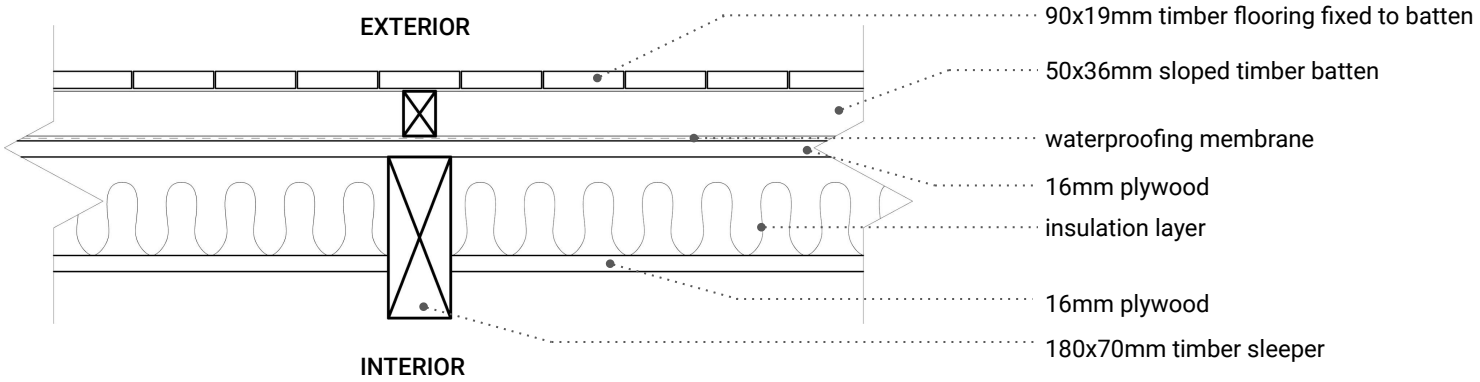
Timber stairs

Bottom timber flooring

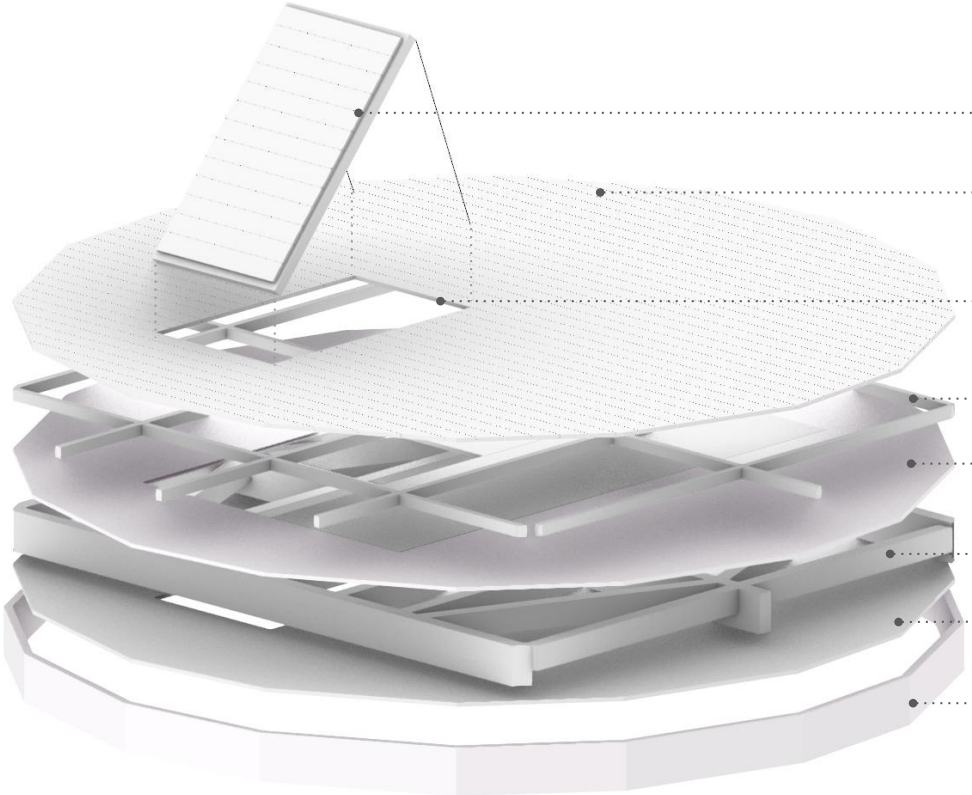
Double skin - fabric (inner) + bamboo layered half culm panels (outer)

Original concrete foundation

Construction Details | Floor Waterproofing



Construction Details | Floor Waterproofing // Exploded Axo



Hinged opening in floor

Timber decking

Opening in floor with timber ladder

Sloped timber battens

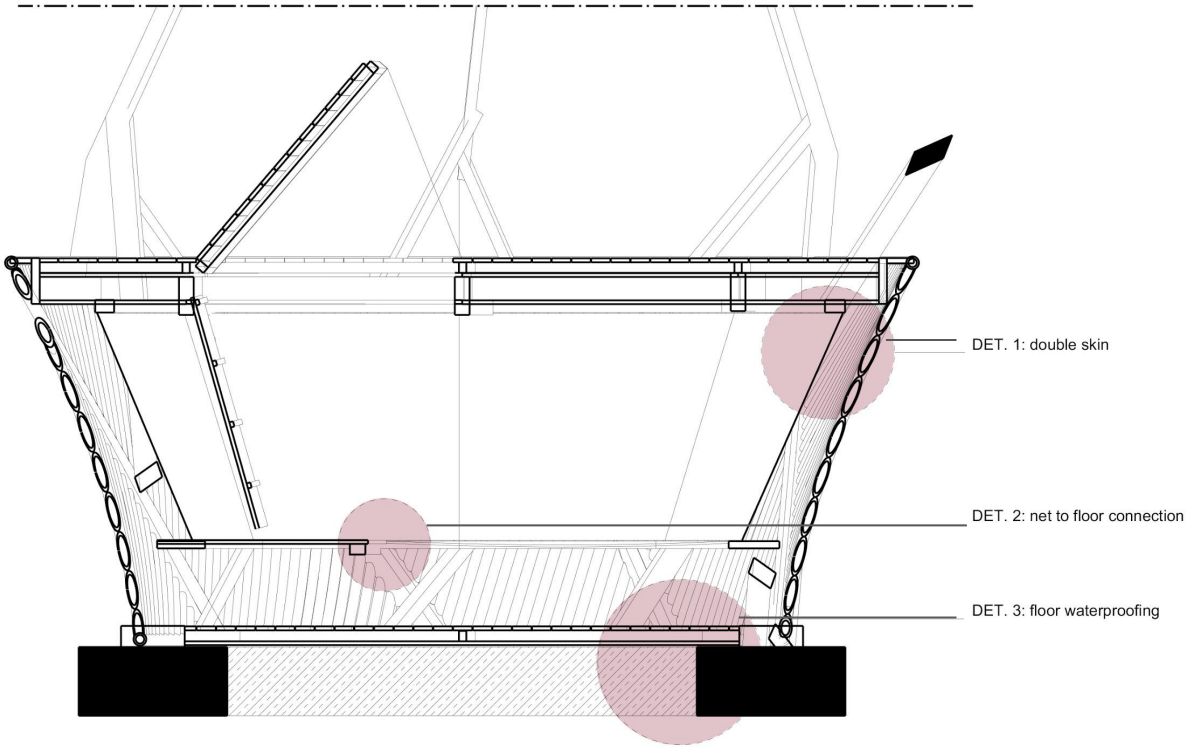
Plywood with waterproof membrane above

Timber sleepers with insulation in between

Plywood

Timber joists

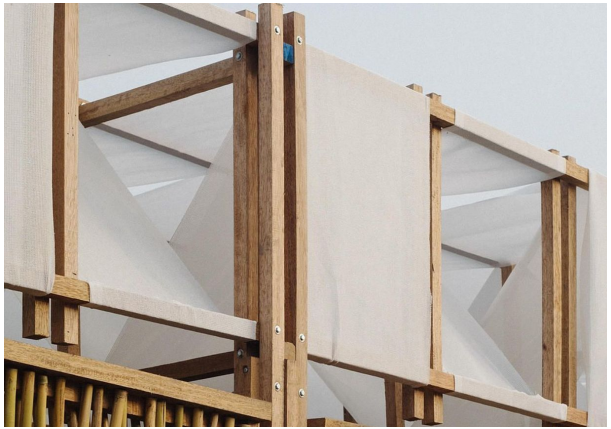
Construction Details | Bottom section



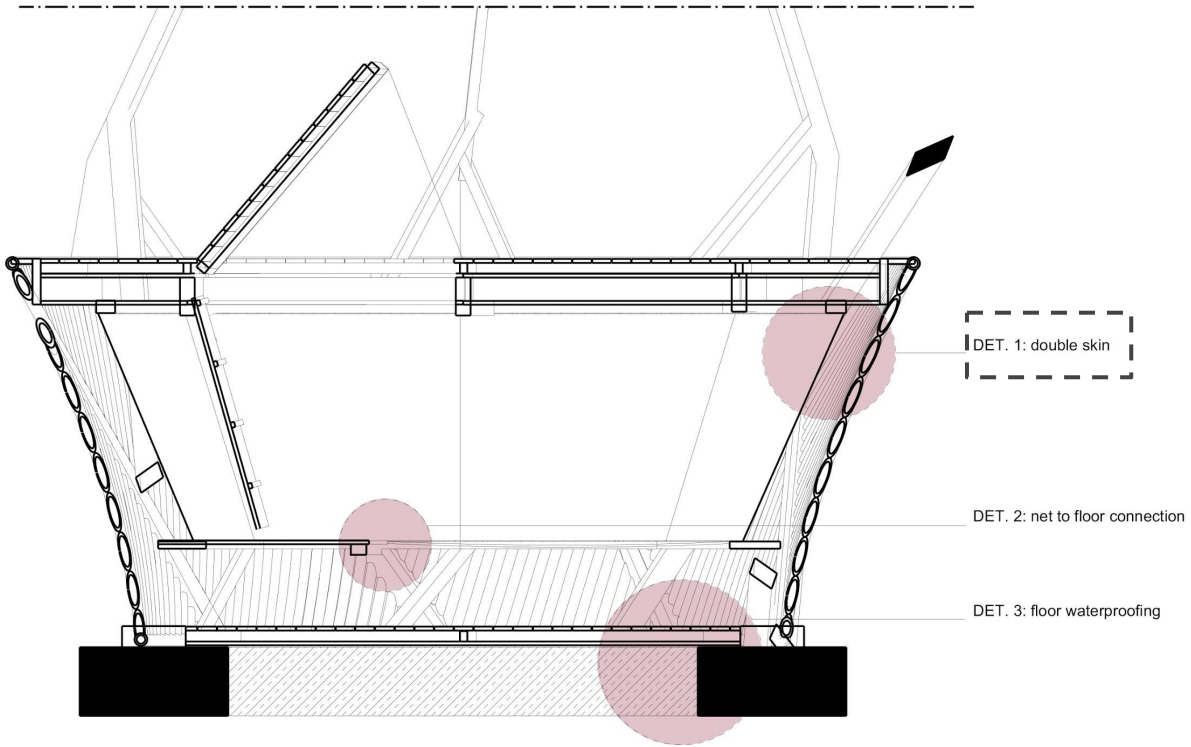
Reference | Bottom section - Detail 01



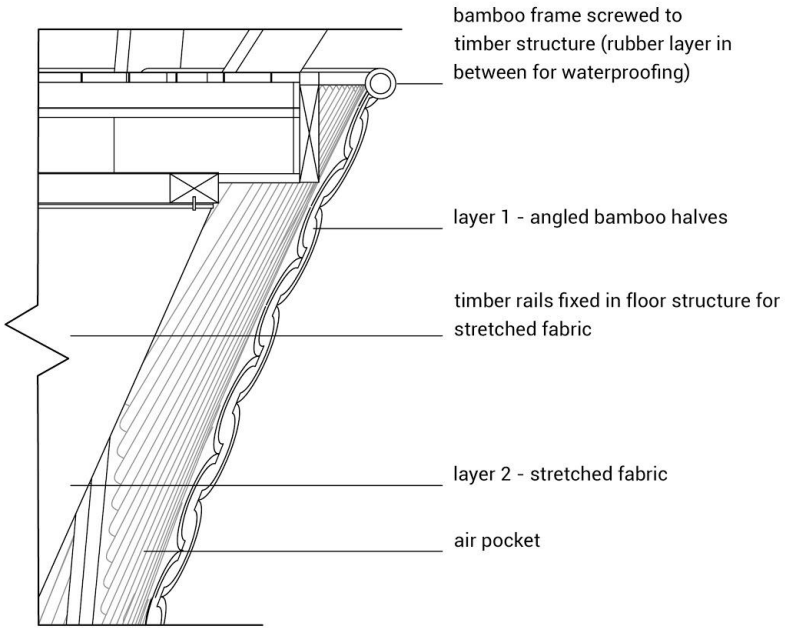
Swirling Cloud: Bulletin Pavilion for BJFU Garden Festival // SUP Atelier // China



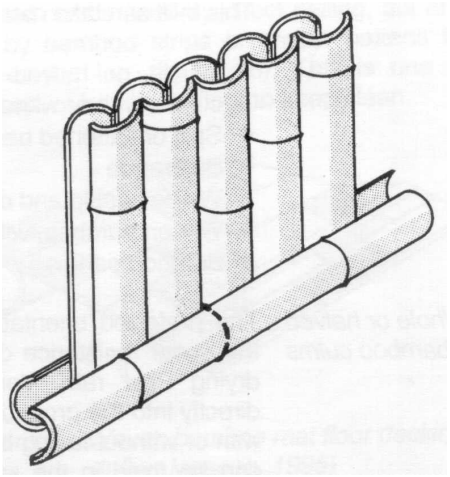
A Room for Archaeologists and Kids in Pachacamac // ETH Zurich + PUCP // Peru



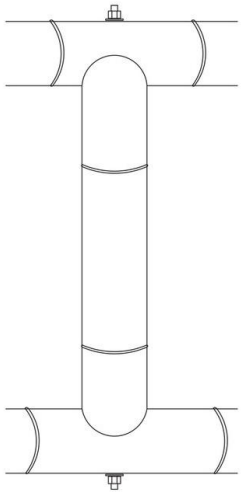
Construction Details | Bottom section



DETAIL 1: double skin

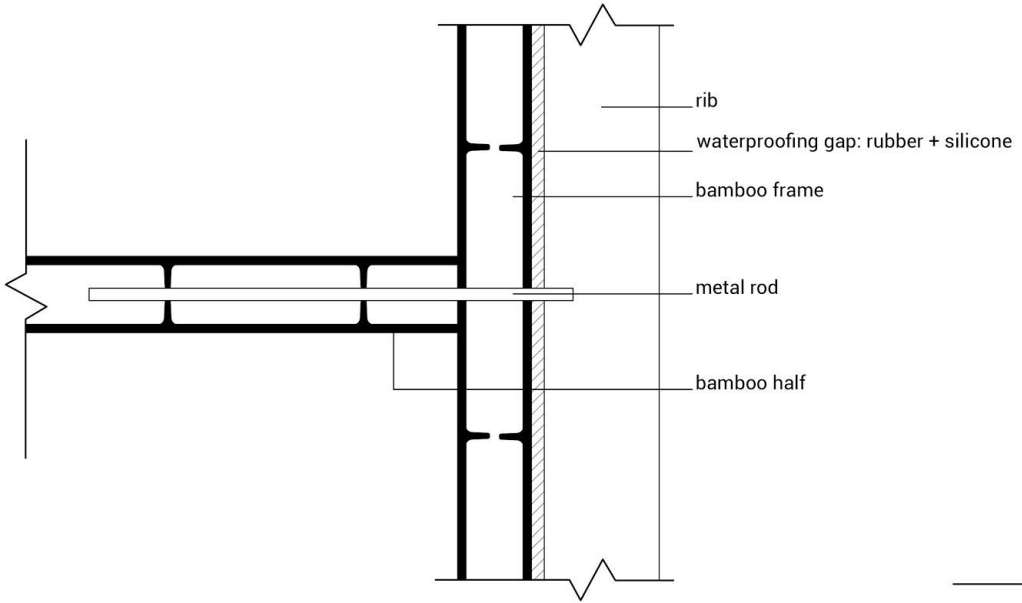


Vertical Bamboo Halves

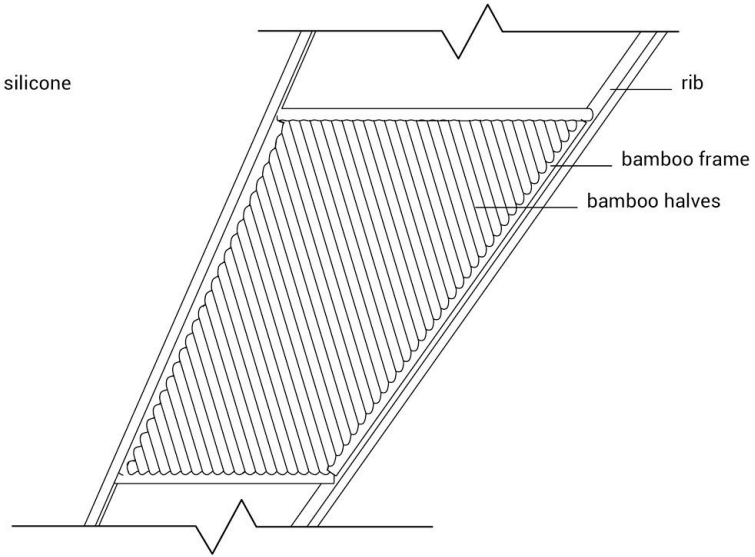


Connection between bamboo rods - panel frames

Construction Details | Bottom section

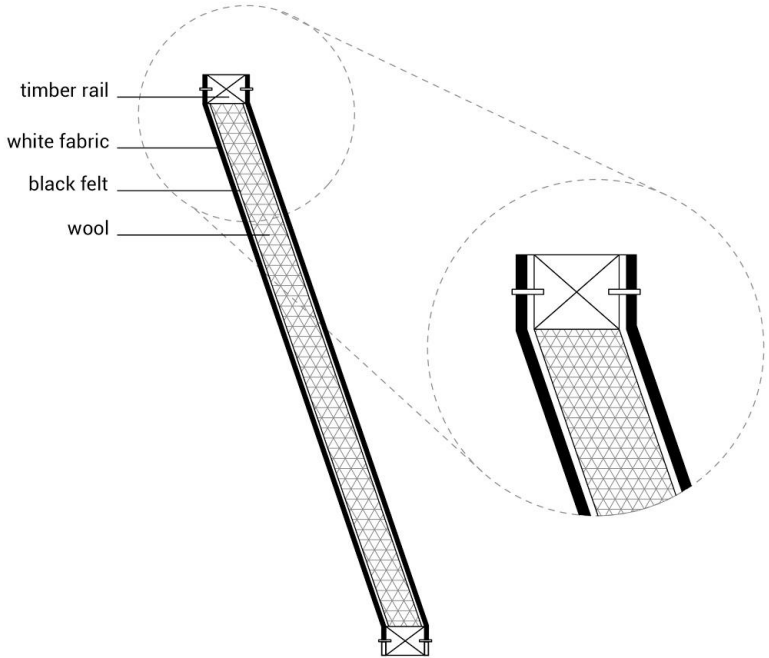


Connection - bamboo
halves to frame to structure



ELEVATION - prefabricated
bamboo panel

Construction Details | Bottom section



SKIN 2 - fabric
insulation layer

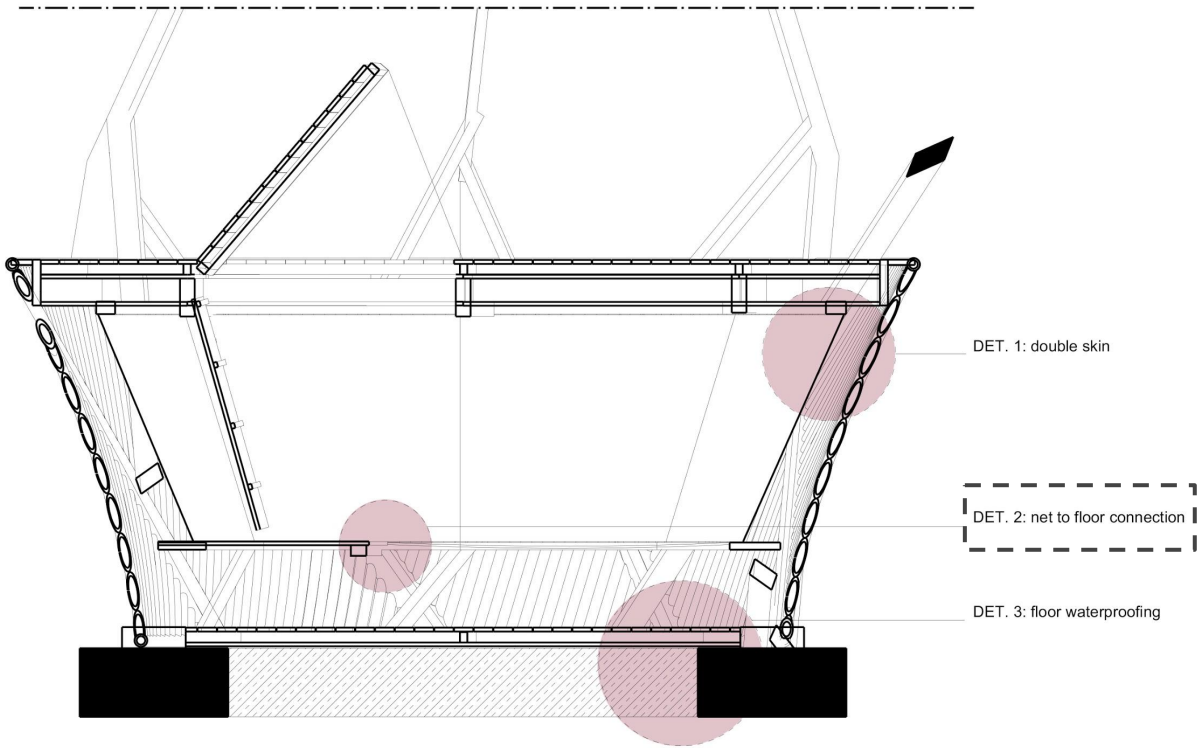


Yurt 2.0, IAAC, 2019; Justin Sheinberg, Tarek Kassouf, Tomithy Ka Kui Lam, Surayyn Uthaya Selvan

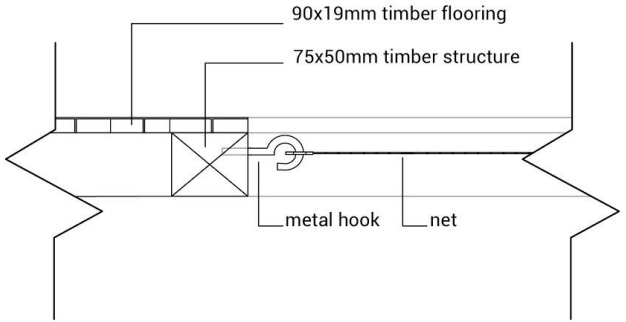
Reference | Bottom section // Detail 02



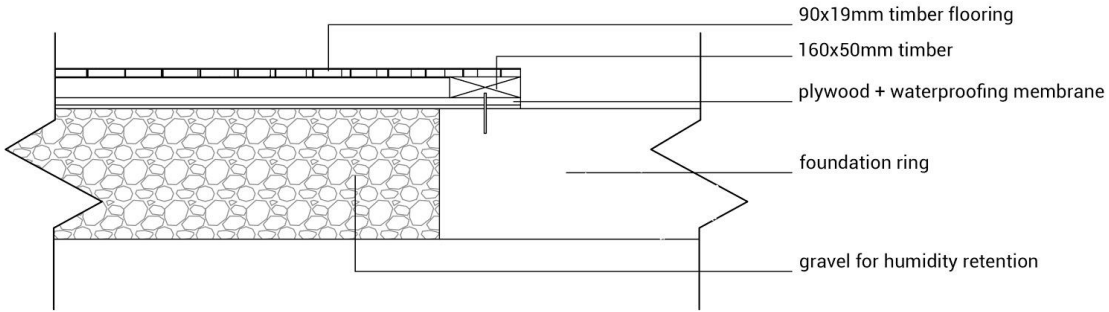
House in Sukumo // Container Design // Japan



Construction Details | Bottom section



DETAIL 2: net to floor connection



DETAIL 3: floor waterproofing